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THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS
OF
ATOMIC BOMBS
ON
HEALTH AND MEDICAL SERVICES
IN
HIROSHIMA AND NAGASAKI

Medical Division

March 1947

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This report was written primarily for the use of the United States Strategic Bombing Survey in the preparation of further reports of a more comprehensive nature. Any conclusions or opinions expressed in this report must be considered as limited to the specific material covered and as subject to further interpretation in the light of further studies conducted by the Survey.

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FOREWORD

The United States Strategic Bombing Survey was established by the Secretary of War on 3 November 1944, pursuant to a directive from the late President Roosevelt. Its mission was to conduct an impartial and expert study of the effects of our aerial attack on Germany, to be used in connection with air attacks on Japan and to establish a basis for evaluating the importance and potentialities of air power as an instrument of military strategy, for planning the future development of the United States armed forces, and for determining future economic policies with respect to the national defense. A summary report and some 200 supporting reports containing the findings of the Survey in Germany have been published.

On 15 August 1945, President Truman requested that the Survey conduct a similar study of the effects of all types of air attack in the war against Japan, submitting reports in duplicate to the Secretary of War and to the Secretary of the Navy. The officers of the Survey during its Japanese phase were:

Franklin D'Olier, *Chairman*.
Paul H. Nitze, Henry C. Alexander,
Vice Chairmen.
Harry L. Bowman,
J. Kenneth Galbraith,
Rensis Likert,
Frank A. McNamee, Jr.,
Fred Searls, Jr.,
Monroe E. Spaght,
Dr. Lewis R. Thompson,
Theodore P. Wright, *Directors*.
Walter Wilds, *Secretary*.

The Survey's complement provided for 300 civilians, 350 officers, and 500 enlisted men. The

military segment of the organization was drawn from the Army to the extent of 60 percent, and from the Navy to the extent of 40 percent. Both the Army and the Navy gave the Survey all possible assistance in furnishing men, supplies, transport, and information. The Survey operated from headquarters established in Tokyo early in September 1945, with subheadquarters in Nagoya, Osaka, Hiroshima, and Nagasaki, and with mobile teams operating in other parts of Japan, the islands of the Pacific, and the Asiatic mainland.

It was possible to reconstruct much of wartime Japanese military planning and execution, engagement by engagement, and campaign by campaign, and to secure reasonably accurate statistics on Japan's economy and war-production, plant by plant, and industry by industry. In addition, studies were conducted on Japan's over-all strategic plans and the background of her entry into the war, the internal discussions and negotiations leading to her acceptance of unconditional surrender, the course of health and morale among the civilian population, the effectiveness of the Japanese civilian defense organization, and the effects of the atomic bombs. Separate reports will be issued covering each phase of the study.

The Survey interrogated more than 700 Japanese military, Government, and industrial officials. It also recovered and translated many documents which not only have been useful to the Survey, but also will furnish data valuable for other studies. Arrangements have been made to turn over the Survey's files to the Central Intelligence Group, through which they will be available for further examination and distribution.

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I. INTRODUCTION

The Medical Division of the Survey selected representative urban and industrial areas in Japan for the study of the effects of aerial bombardment upon the public health and upon health services. As special United States Army and Navy medical missions were making intensive studies of the nature and scope of casualties from the atomic bombs, no special emphasis was placed upon this phase of the general health problem, and the survey at Hiroshima and Nagasaki was conducted along the same lines as in other cities. The information contained herein concerning the nature of casualties from the atomic bombs was largely derived from data obtained from these Army and Navy missions and "The Report of the British Mission to Japan on an Investigation of the effects of the Atomic Bombs Dropped at Hiroshima and Nagasaki" which contains data obtained from the same sources.

The report presented here briefly outlines the immediate and remote measurable effects of the atomic bombs and the subsequent widespread fires on the health of the civilian population. The investigation includes the different phases of public health following the outline used in the over-all health survey of Japan. This report contains chapters which relate to medical and health facilities and services, nature of air-raid casualties, sanitary facilities and services, food supply and nutrition, communicable diseases, and industrial health and hygiene.]

There was a notable difference in the attempted restoration of public health services in the two cities. At Nagasaki, the occupation forces had set up headquarters with an active section on public health in the local military government. This group was supervising and assisting in the restoration of hospitals, clinics, disease reporting

and control, and the various necessary health services. At Hiroshima, however, the local public health program had been largely delegated to Japanese officials, who had taken over several buildings for use as hospitals, and had assisted in the reoccupation of the Red Cross Hospital which had ceased operation as a result of the bombing. Teams of Japanese physicians and medical students from the large medical centers were carrying on limited treatment of bomb victims.

SURVEY STAFF

The staff of the Medical Division of the Survey consisted of six officers and one civilian from the Public Health Service, three officers and four enlisted men from the Army. The Chief of the Medical Division, Brig. Gen. Lewis R. Thompson, Assistant Surgeon General, United States Public Health Service, could select freely the Public Health Service officers attached to the Survey, and chose officers known for their ability in certain fields of public health work. The Army and Public Health Service officers detailed to these several fields were: Maj. Luther L. Terry, United States Public Health Service, medical facilities and personnel and nature of bomb casualties; Lt. Col. Robert H. Flinn, United States Public Health Service, industrial health and hygiene; Maj. Robert S. Goodhart, United States Public Health Service, and Maj. Henry J. Rugo, A. U. S., food supply and nutrition; Maj. Jesse Yaukey, United States Public Health Service, communicable diseases; Col. Ralph O. Tarbett, United States Public Health Service, and Capt. Paul J. Houser, A. U. S., sanitary facilities and services. Mr. Lester J. Marier of the United States Public Health Service acted as executive secretary for the Medical Division.

II. EFFECTS ON MEDICAL FACILITIES AND PERSONNEL

In order to appreciate the effects of the atomic bombs on Hiroshima and Nagasaki one must realize something of the character and extent of medical institutions in the two cities. In addition, it is important for one to realize the magnitude of the destructive forces since they so completely surpass all previous concepts of destruction that one might have when thinking in terms of ordinary incendiary or high-explosive bombing.

A. STATUS OF MEDICAL CARE PRIOR TO BOMBING

1. Generally speaking, the Japanese are not accustomed to good medical care as one uses the term in light of practice in the Western world. Hospitals are usually available to only those who are able to pay and the average Japanese citizen has never been educated to the value and use of hospitals. Though the number of physicians per unit of population compares favorably with that in the United States, the average physician is poorly trained and the character of medicine which he practices is far below Western standards. Even the licensed physicians resort to unconventional and unscientific methods which have their origin in Far-Eastern religion and superstition. In addition, the government licenses a group of "persons engaged in the traditional methods of treatment," such as acupuncture, massage and moxa. There are also a large number of unlicensed cultists who treat persons by means of faith healing. Both the licensed and unlicensed cultists have fairly large followings, particularly in the rural population and the lower classes

2. The average Japanese hospital is a small private hospital which consists of 10 to 50 beds. Actually, the term "beds" is used loosely in this respect since few of them have western-style beds. The rooms in such hospitals are very much like rooms in Japanese homes with tatami floors and beds made by spreading bedding (Futon) upon the floor. It is thus impossible to give an accurate bed capacity, this figure actually representing the number that can be crowded into the available space. On the other hand, the larger city institutions and university hospitals are usually well equipped, of modern construction and use western beds throughout. Despite this fact, there are in every city large numbers of these small Japanese-style hospitals. Too, a large

percentage of the population never go to hospitals, but are born, have their illnesses and babies, and die in their own homes. Most of the births in Japan are attended by midwives.

3. Hiroshima and Nagasaki did not differ from the usual medium-sized Japanese city. Hiroshima had two Army hospitals and an Army-Navy relief hospital in addition to the civilian institutions. The Red Cross Hospital and the Communications Hospital were modern structures and were the better institutions of the city. In addition there were many small Japanese hospitals scattered over the city. In the spring of 1945 a medical college was started in Hiroshima and the first class had matriculated. Though no school building was available they were being taught in one of the local hospitals at the time of the bombing. The supply of doctors and nurses seemed up to Japanese standards and it was thought that the city was well provided with medical care.

4. The situation in Nagasaki differed from Hiroshima in that it possessed one of the finest medical centers in Japan. The University Hospital was the pride of the city and was reputed to be second to none in Japan except the Imperial University Hospital in Tokyo. It was a large modern unit consisting of many buildings and contained about 500 beds. This number represented more than three-quarters of the hospital facilities in the city. The Medical College was located near the hospital and had a large staff of well trained teachers. There were in addition a tuberculosis sanatorium and many small private and industrial hospitals. Here too, the number of physicians and nurses seemed to be adequate in comparison to other Japanese cities.

5. Since most of the other large cities of Japan had been subjected to demolition and incendiary raids during late 1944 and 1945 it was natural for Nagasaki and Hiroshima to expect similar treatment. Hiroshima contained no large war industries and had been bombed on one previous occasion only. At that time a single B-29 had dropped several demolition bombs on a suburban district but there was little damage done. Nagasaki had experienced demolition bombing on several occasions but these raids were directed at key industrial plants. On 1 August 1945, 6 bombs were dropped on the University Hospital hitting the operating room and laboratories and

resulting in the death of 3 students and 30-40 other casualties. Many patients were then evacuated as an air-raid precaution. The fact that Hiroshima had been so completely spared of bombing apparently gave rise to some rumors that the city was being saved for some "fantastic" weapon. Several survivors relate having heard such rumors. There was, however, no real reason to suspect that any fate other than that experienced by other cities was in store for it. Accordingly, the officials proceeded with the creation of large firebreaks. This work was started in March 1945 and continued until the time of the atomic bombing. Thousands of homes were thus destroyed and their occupants were required to leave the city. It was estimated by the Prefectural Health Officer that 150,000 people were evacuated from Hiroshima from March to August 1945, of whom probably 10,000 had returned. Similar preparations were being carried out in Nagasaki but they appear to have been on a somewhat smaller scale.

B. THE ATOMIC BOMBING

1. It was upon the previously-described conditions that the atomic bombs were dropped on Hiroshima on 6 August and on Nagasaki three days later. In order to appreciate the conditions at the time of the blast and immediately thereafter it will be well to reconstruct the scene in Hiroshima as best it can be determined from talking with survivors.

2. The morning of 6 August 1945 began bright and clear. At about 0700 there was an air-raid alarm and a few planes appeared over the city. Many people within the city went to prepared air-raid shelters, but since alarms were heard almost every day the general population did not seem to have been greatly concerned. About 0800 an all-clear was sounded after the planes had disappeared. At this hour of the morning many people were preparing breakfast. This fact is probably important since there were fires in charcoal braziers in many of the homes at this time. Some of the laboring class were at work but most of the downtown business people had not gone to work. Consequently, a large percentage of the population was in their homes and relatively few were in the more strongly constructed business buildings.

3. After the all-clear sounded persons began

emerging from air-raid shelters and within the next few minutes the city began to resume its usual mode of life for that time of day. It is related by some survivors that they had watched planes fly over the city. At about 0815 there was a blinding flash. Some described it as brighter than the sun, others likened it to a magnesium flash. Following the flash there was a blast of heat and wind. The large majority of people within 3,000 feet of ground zero were killed immediately. Within a radius of about 7,000 feet almost every Japanese house collapsed. Beyond this range and up to 15,000-20,000 feet many of them collapsed and others received serious structural damage. Persons in the open were burned on exposed surfaces, and within 3,000-5,000 feet many were burned to death while others received severe burns through their clothes. In many instances clothing burst into spontaneous flame and had to be beaten out. Thousands of people were pinned beneath collapsed buildings or injured by flying debris. Flying glass particularly produced many non-lethal injuries at greater distances from the center of the blast. Details relative to the nature of the injuries and the distances at which they occurred are discussed in the following chapter, but the foregoing presentation was necessary for one to appreciate the state of the population immediately after the bomb exploded.

4. Shortly after the blast fires began to spring up over the city. Those who were able made a mass exodus from the city into the outlying hills. There was no organized activity. The people appeared stunned by the catastrophe and rushed about as jungle animals suddenly released from a cage. Some few apparently attempted to help others from the wreckage, particularly members of their family or friends. Others assisted those who were unable to walk alone. However, many of the injured were left trapped beneath collapsed buildings as people fled by them in the streets. Pandemonium reigned as the uninjured and slightly injured fled the city in fearful panic. Teams which had been previously organized to render first aid failed to form and function. Those closer to ground zero were largely demobilized due to injuries and death. However, there were physically intact teams on the outskirts of the city which did not function. Panic drove these people from the city just as it did the injured who could walk or be helped along. Much of the city's fire-fighting equipment was damaged beyond

use so that soon the conflagrations were beyond control.

5. In Nagasaki a similar but slightly less catastrophic picture occurred. The blast was not centered over the main business section of the city but was up the valley about 2 miles. There were large industrial plants, hospitals, the medical school and partially built-up residential areas near the ground zero. The terrain in this area was uneven with large hills which shielded certain areas. Due to the shielding factor and the distance of the explosion from the center of the city, Nagasaki was less completely destroyed than Hiroshima and the panic was apparently less.

C. THE FATE OF MEDICAL FACILITIES

1. The fate of the hospitals in Hiroshima is particularly interesting in the light of this chaos and destruction. Many of the smaller hospitals and clinics were located in the center of the city and were of typical Japanese construction. For instance, the Shima Surgical Hospital (Fig. 1) was only 100 feet from ground zero. It was partly brick but largely wooden construction. The blast blew it flat, and it is believed that all of the occupants were killed immediately. The remains of the building burned, and the spot is now a mass of flattened rubble. The Tada Hospital was partly reinforced concrete and partly wooden construction. Located at 2,600 feet from ground zero it was completely demolished, and the only remnants were the concrete foundation and the gutted and broken concrete portions of the building (Fig. 2). The exact fate of its occupants could not be definitely determined but it is believed that they were all killed by the blast and succeeding fire. Another building of medical nature which was located near the center of the blast was the Japan Red Cross Office Building. It was only 740 feet from ground zero and was almost completely demolished. The windows, window casements, and doors were blown out and even the concrete structure was broken by the downward thrust of the blast. The building was then gutted by fire and all occupants perished (Figs. 3 and 4). The Hiroshima Army Hospitals No. 1 and No. 2 were located within 1,500–2,000 feet of ground zero. It is reported that 80 percent of the personnel and all of the patients (500 in No. 1 and 650 in No. 2) were killed. The ultimate fate of the surviving 20 percent of the personnel is not known,

but on the basis of other experiences at this distance it is probable that a large percentage of them died of injuries or radiation effects. The hospital buildings collapsed and burned. The Red Cross Hospital, which was the city's largest and best hospital, was located 4,860 feet from ground zero. The basic structure of the building, which is reinforced concrete, remained virtually intact. However, steel window casements were blown out or twisted and torn on the side near the blast (Fig. 5) and the interior was seriously damaged by falling plaster, broken partitions, and falling ceilings (Fig. 6). There were 90 percent casualties of the occupants of this building and the damage was so great that the hospital ceased operation for several weeks after the bombing. It did, however, serve as a first-aid station and out-patient clinic in the interim. Practically all instruments and supplies in this hospital were completely destroyed or damaged beyond repair. The Hiroshima Communications Hospital was located at a similar distance from the ground zero, 4,900 feet. It, too, was of reinforced-concrete construction. Though the concrete framework of the building remained intact it suffered even more severe damage than did the Red Cross Hospital. Steel window casements were blown out, partitions blown down, and all of the contents were damaged beyond repair (Fig. 7). It was later reoccupied as were most of the buildings which were left standing. An example of a hospital located at greater distance from ground zero is the Army-Navy Relief Hospital. It was 10,400 feet from the ground zero and sustained considerable damage (Figs. 8, 9, and 10). The building was stucco and two floors in height. Though it did not collapse, it was seriously damaged. Most of the tile roof was broken and blown off, window frames were broken and blown out, and in a few places walls were crushed. The principal injuries to the occupants of this hospital were due to flying glass and other missiles. Many smaller hospitals and clinics were destroyed in similar manner, depending upon their distance from the center of the blast. Since practically all of these buildings were of wooden construction they were either blown down and/or burned shortly thereafter. There was little evidence of their existence to one who came into the area later. It has been impossible to trace the fate of their occupants but it is felt that it coincided to some extent with the fate of other persons in Japanese-type homes



Figure 1.—The rubble in the foreground is the only remains of the Shima Surgical Hospital, Hiroshima, which was only 100 feet from ground zero.



Figure 2.—Tada Hospital, Hiroshima, located 2,600 feet from ground zero. Inflammable portion of building burned and remainder was completely gutted.



Figure 3.—Japanese Red Cross Office Building, Hiroshima, 740 feet from ground zero.



Figure 4.—Interior of Japanese Red Cross Office Building, Hiroshima. Building was completely gutted and structural damage shows effects of downward thrust of blast. All occupants were killed.



Figure 5.—Exterior view, rear, of Red Cross Hospital, Hiroshima, 4,860 feet from center of blast. Note destruction of surrounding properties and damage to the building itself.



Figure 6.—Interior, first floor, Red Cross Hospital, Hiroshima; 90 percent of occupants were casualties and hospital ceased operation for some time.



Figure 7.—Hiroshima Communications Hospital, 4,900 feet from ground zero. Though the basic structure was not damaged, there was considerable functional damage and many injuries to occupants.



Figure 8.—Front view of Army-Navy Relief Hospital, Ujina, Hiroshima, located 10,400 feet from ground zero.



Figure 9.—Army-Navy Relief Hospital, Hiroshima. Note structural damage even at distance of 10,400 feet.



Figure. 10.—Exterior view of Army-Navy Relief Hospital, Hiroshima. Moderate damage was sustained by the building and many occupants suffered injuries due to flying glass and other missiles.

at similar distances from ground zero. Actually the incidence of flash burns was probably lower, since few of them would have been outdoors, but the secondary injuries were probably higher. Inasmuch as they were already ill and many no doubt were helpless, the mortality rate surely exceeded that of the general population at comparable distances.

2. Thus it may be said of Hiroshima that essentially all of the civilian hospitals and 2 large Army hospitals were located within 5,000 feet of ground zero and were functionally completely destroyed. Those within 3,000 feet were totally destroyed and the mortality rate of the occupants was practically 100 percent. Two large hospitals of reinforced concrete construction were located 4,860 and 4,900 feet from the ground zero. The basic structures remained erect but there was such severe interior damage that neither was able to continue operation as a hospital. The casualty rate in these 2 hospitals was approximately 90 percent. Hospitals and clinics beyond 7,000–10,000 feet often remained standing but were badly damaged and there were many casualties due to flying glass and other missiles.

3. The destruction of hospitals in Nagasaki was even more outstanding than that in Hiroshima. Since the Nagasaki University Hospital contained over three-quarters of the hospital beds in the city it represented the bulk of the city's hospital facilities. The center of the hospital grounds was only 2,400 feet from ground zero and from a functional standpoint the hospital was completely obliterated. Most of the buildings were of reinforced-concrete construction but a great deal of wood was used in interior construction and fittings. The basic structure of all these buildings remained essentially intact but there was severe damage otherwise (Figs. 11–20). The blast effects were very severe and almost every building was gutted by fire. The mortality rate of occupants of this hospital was at least 80 percent, two-thirds being killed outright. The Nagasaki Medical College was located even closer to ground zero, being only 1,700 feet distant. A large portion of the buildings were of inflammable nature but a few small buildings were constructed of reinforced concrete. The wooden buildings were blown down and subsequently consumed by flames. The concrete structures remained erect but were completely gutted by fire (Figs. 21–25). Of the 850 medical students present 600 were killed and 12 of the 16

professors were also lost. The third and fourth year medical students escaped by virtue of the fact that they were elsewhere at the time of the bomb blast. Almost all of the other occupants of the buildings were killed outright. All medical equipment and supplies in the medical college buildings were completely destroyed by blast and fire. The Nagasaki Tuberculosis Sanatorium was located across the valley from the college and the hospital but was only 2,600 feet from ground zero. Since the buildings were all of wooder construction they were completely destroyed by blast and fire (Fig. 26). It was reported that all of the patients and other occupants of the sanatorium were killed. Except the 2 hospitals mentioned above there were no others of any size located within Nagasaki, although there were many small private hospitals and clinics of typical Japanese construction, scattered throughout the city. The fate of these buildings and their occupants corresponded in general to that of buildings of similar construction at comparable distances from the bomb in Hiroshima. However, there was an additional factor of the hills shielding some structures in Nagasaki. In Hiroshima the effective zone was entirely flat and hills on the outskirts of the city were so distant that they did not interfere with the effects of the bomb to any appreciable extent. On the other hand, in Nagasaki many structures that would otherwise have suffered much more severe damage were partially or completely protected from the bomb effects by hills.

4. In summary, it may be said of the hospital facilities in Nagasaki that over 80 percent of the hospital beds and the Medical College were located within 3,000 feet of ground zero and were completely destroyed. Reinforced-concrete buildings within this range remained standing but were completely gutted by fire; buildings of wooden construction were completely destroyed by fire and blast; the mortality rate of occupants of this group of buildings was about 75–80 percent.

D. RESTORATION OF HOSPITALS AFTER BOMBING

1. An amazing feature of the atomic bombings to one going into the areas later was the poor recuperative powers of the population towards the restoration of all types of facilities. Though this was probably less so in the medical field than in others it was still alarmingly apparent. The



Figure 11.—Exterior of Building 17, Nagasaki University Hospital. The center of hospital buildings was 2,400 feet from ground zero. Note severe destruction despite bomb-resistance of the basic structure of the building.



Figure 12.—Side view of Building 33, Nagasaki University Hospital, showing extensive functional damage.



Figure 13.—Building 13, Nagasaki University Hospital, showing degree of destruction.



Figure 14.—Buildings 35, 36 and 17, Nagasaki University Hospital.



Figure 15.—Interior of amphitheater of Nagasaki University Hospital. Brass rails around the balcony were melted by the intense heat.



Figure 16.—View of corridor in one of the fireproof buildings, showing wreckage and complete burn-out of interior.



Figure 17.—Burned-out ward in one of the north buildings of Nagasaki University Hospital.



Figure 18.—View of one of the less severely damaged rooms of Nagasaki University Hospital.



Figure 19.—Third floor corridor of Building 2 showing extent of damage.



Figure 20.—Oculist examining room on second floor of Building 3, Nagasaki University Hospital.



Figure 21.—General view of central portion of Medical College, Nagasaki. The center of the college was 1,700 feet from ground zero.



Figure 22.—South end of grounds of Nagasaki Medical College. One small reinforced concrete building is standing but all others were destroyed by blast and fire.



Figure 23.—View of grounds of Nagasaki Medical College showing little rubble after complete destruction of surrounding buildings.



Figure 24.—Interior of library, Nagasaki Medical College. All papers and volumes were completely consumed by fire.



Figure 25.—Reinforced concrete record vault on second floor. There were small steel casement windows on two sides away from the blast but solid walls on the near side. Records stored under stairway were burned to ashes.



Figure 26.—Ruins in foreground represent remains of tuberculosis sanatorium, Nagasaki. The buildings were 2,700 feet from ground zero and were of inflammable construction.

panic of the people immediately after the bombing was so great that Hiroshima was literally deserted. It was apparently less true of Nagasaki and this was probably due to the fact that the city was less completely destroyed, but the same apathy was there. The colossal effects of the bombs and the surrender following shortly thereafter seemed to have completely stunned the people. The effects of the typhoons of September and early October may have contributed to this psychological reaction.

2. Since the most outstanding feature of the atomic bombs was the high rate of human casualties, it was natural that this was the greatest problem in the areas following the bombing. But even in this regard the progress was astoundingly slow and haphazard. Other evidences of restoration were almost completely absent. For instance, at the time the Medical Division visited Hiroshima, 3 months after the bombing, the first street car was beginning operation, people wandered aimlessly about the ruins, and only a few shacks had been built as evidence of reoccupation of the city. No system for collection of night soil or garbage had been instituted. Leaking water pipes were seen all over the city with no evidence of any attention. It was reported that following the bombing several days were required for disposal of the dead and then they were simply piled into heaps and burned without attempts at identification or enumeration. Street cars were burned as a method of cremating the bodies within. All in all, there appeared to be no organization and no initiative.

3. The care of the wounded immediately after the bombing was essentially nil in Hiroshima. Beyond the sphere of family ties there seemed to be little concern for their fellow man. It is true that essentially all of the medical supplies were destroyed by the bombing, and that there were no hospitals and little with which to work. For the first 3 days there was no organized medical care. At the end of this time the Prefectural Health Department was successful in getting a portion of the surviving physicians together and to begin ministering to the wounded who remained in the city. Up until this time all nursing and medical care had been on an individual basis. The more seriously injured were placed in the few remaining public buildings on the outskirts of the city. Many of them died but many seriously burned cases remained. Small stocks of medical

supplies which had been stored in caves outside the city were brought out but were soon exhausted. With all medical supplies gone and practically none being brought in the treatment of the injured seems to have consisted largely of offering a place of refuge. There is no doubt that many died who might have been saved by modern, competent medical care. As time elapsed many of the small hospitals and clinics were able to reopen and offer some help. Japanese medical authorities and other scientists visited the city in order to appraise the nature and extent of the damage but they did not contribute materially to the care of the sick and injured. Finally, medical teams consisting of medical students and physicians were sent into the area from the larger cities such as Tokyo, Osaka and Kyoto. They assisted materially in administering medical care but were handicapped by the overwhelming size of the task and the lack of supplies. The Red Cross Hospital was cleared of wreckage and finally reopened without any repair of the building. In many respects it was fortunate that such a large proportion of the injured fled to nearby towns and villages. Except for Kure which had been largely destroyed by incendiary bombing, the facilities in these areas were relatively intact.

4. Soon after American occupation forces entered the area some medical supplies were made available. A medical unit representing the Surgeon General of the United States Army was assigned to the project. The task of this unit was largely investigative in nature but they did assist the Japanese authorities in organizing and directing medical relief for the bomb victims. The American physicians did not treat any of the cases. In the first place they arrived so late (about 1 October) that deaths from radiation had practically ceased. Secondly, they did not have supplies and personnel to perform a thorough study of methods of treatment. Thirdly, it was apparently felt that investigation of the nature of the casualties was more important. And finally, with these facts in mind the Americans had a clear understanding with the Japanese that they would assume no responsibility for the treatment of cases but would merely consult with and advise the Japanese whenever necessary. In time a large rayon factory in Ujina and other buildings were taken over by the Japanese Government and utilized as hospitals. Some of the injured found their way to distant cities for

treatment and other groups were officially transferred by the Japanese Government to medical centers in Osaka, Kyoto, and Tokyo for study and treatment.

5. Most of the fatalities due to flash burns and secondary injuries occurred within a few days after the bombing. The peak of deaths due to radiation effects was not reached until late August or the early part of September. Very few cases suffering from radiation died after 1 October and deaths due to other causes had practically ceased by this time. Thus during October the essential medical care was directed almost exclusively toward burn cases, most of which were flash burns. A large number were still in hospitals but the vast majority of these patients could be treated as outpatients. By 1 November adequate hospital space was available but it was still of emergency nature and medical supplies were inadequate. Many of the burns remained unhealed. Inadequate medical care, poor nutrition, and secondary infection were important factors in this delayed healing.

6. The effects of the atomic bombing of Nagasaki were very similar to those in Hiroshima. Even though it followed the bombing of Hiroshima by 3 days, wartime secrecy, general confusion and the short elapse of time did not allow the population of Nagasaki any particular advantage from the previous experience. The psychological reaction of the people was essentially the same and the chaos in the city seems to have been almost as great. A very important difference between the two cities was that Nagasaki was not so completely destroyed. Further, the bomb blast was centered over a more industrial area and the character of the buildings resulted in less extensive fires. But from the medical standpoint the bombing was particularly catastrophic because the bulk of the city's hospital facilities were located within a radius of 3,000 feet of the center of the explosion. The destruction of the University Hospital and the Medical College was so great that the buildings left standing could not be reoccupied even for emergency medical care. Other hospitals and clinics, including the Tuberculosis Sanitorium, had burned to a heap of ashes. The only remaining facilities were small private clinics and hospitals and many of them were seriously damaged. Essentially no organized medical care was carried out for several days after the bombing. The Shinkosen hospital was established in an old school building

for the care of bomb victims, but it was woefully inadequate. At one time it harbored over 500 victims. Fortunately, there was a large medical depot at Omura, 20 miles away. Such large stocks of supplies were on hand here that Nagasaki did not suffer in this respect as did Hiroshima. Another school building was converted into an infectious disease hospital.

7. At the time the Allied Military Government entered Nagasaki, about 1 October, the population was found to be apathetic and profoundly lethargic. Even at this time the collection of garbage and night soil had not been reestablished, restoration of other public utilities was lacking and the hospital facilities were inadequate. Through the initiative of the Military Government, a system of reporting infectious diseases was instituted, the collection of garbage and night soil was reestablished, and attempts were made to increase the supply of safe water. A survey of the remaining hospitals and clinics at this time by Captain Horne of American Military Government revealed such obvious inadequacies that the survey was not even completed. A perusal of the incomplete report reveals that there were many small private hospitals remaining, most of which were damaged and without satisfactory potential value even if they were repaired. In the face of the inadequacy of the Shinkosen Hospital, and the absence of other facilities in Nagasaki, bomb victims were transferred to the Omura Naval Hospital where the conditions were much better. The Shinkosen Hospital has now been evacuated and abandoned.

8. When Nagasaki was visited by the Medical Division, about three months after the bombing, conditions were still very primitive. A visit to the Infectious Disease Hospital revealed that the school building in which it was located had been seriously damaged by bombing and no repairs had been made. The roof was partially destroyed, there were no window panes and the building was filthy. All of the patients, both male and female, were in adjacent beds in the same ward. Members of their families were present and were going in and out at will. The hospital had a capacity of 35 beds and contained 21 patients; 18 cases of dysentery and 3 cases of typhoid fever, at the time of the visit. There were no isolation precautions in practice. The only medicine and supplies were those furnished by the Military Government. Because of these conditions the Military Government had taken over a Japanese

Army hospital of 103 beds and 12 bassinets and was converting it for use as a Japanese civilian hospital. It was expected to be available very shortly thereafter. The Omura General Hospital (formerly a Naval hospital) was in excellent condition and was being used for the care of atomic bomb victims. Thus, it may be seen that by 1 November some semblance of medical care and sanitary procedures had been reestablished in Nagasaki but the facilities were still inadequate. The entire program had to be directed and forced by the Americans though they did not enter the area until nearly 2 months after the bombing.

9. The devastating effects of the atomic bombs upon medical facilities can be appreciated in the light of the foregoing presentation. Not only were the existing facilities almost completely destroyed but there was extreme apathy toward the restoration of hospitals and the care of the injured.

E. EFFECTS ON MEDICAL PERSONNEL

1. It was almost impossible to get any accurate information relative to the number of doctors, nurses and other medical personnel in the area prior to bombing, the number injured and killed, or even the number actually present at the time of the visit by the Medical Division. Data obtained from various sources showed extreme variation and were often unreliable. Naturally, the medical personnel in general met the same fate as others located at the same distances from the bomb. The number of casualties also probably bore a direct relationship to the fate of hospitals since medical personnel would be concentrated at those institutions and roughly in proportion to the size of the hospital or clinic.

2. The number of physicians in Hiroshima prior to the bombing has been variously estimated from 200 to 298. The former figure was supplied to the Medical Division by the Prefectural Health Officer and the latter figure was included in an address by the Prefectural Governor on 9 September 1945. The actual figures probably fall between these two extremes. Regardless of the total number it is known that the casualty rate among this group was very high. About 90 percent were casualties and 60 of these physicians were killed. One month later only 30 physicians were able to perform their usual duties.

3. The Hiroshima Prefectural Medical College was started in the spring of 1945 and the first

class had matriculated. As a result of the bombing the hospital was demolished and one member of the faculty was killed and another injured. The number of students killed and injured could not be determined.

4. Prior to the bombing there were 1,780 nurses in Hiroshima. Of these, 1,654 were killed or injured on 6 August. Consequently, the city suffered greatly because of the lack of nurses and many untrained volunteers had to be pressed into service in caring for the injured.

5. The experience in Nagasaki was very similar to that in Hiroshima. The exact number of physicians in the city prior to the bombing could not be determined but there were probably about 200-250 in 1944. This number may have decreased slightly in 1945 as a result of actual bombing and the effects of partial evacuation of the city in preparation for raids. Due to the different character of the two cities it would at first appear that the loss of medical personnel would have been proportionately less in Nagasaki. However, a factor which counterbalanced this fact to some extent was that the largest number and best of the medical personnel were concentrated in the medical school and the University Hospital, both of which were completely destroyed with a large percentage of their occupants. Actual investigation as of 1 November revealed that there were about 120 physicians in Nagasaki. So apparently the city did fare better than Hiroshima which had less than half that many physicians at about the same time.

6. The damage to the Nagasaki Medical College and University Hospital has already been described. Reports reveal that 600 of the 850 medical students were killed and some others may have died later. Of the survivors practically every one was injured and at least half had radiation sickness later. There were 16 of the 20 faculty members present at the time of the bombing and 12 of them were killed and the others injured.

7. The casualty rate among nurses in Nagasaki could not be accurately determined. There were 683 nurses in the city on 1 November but it is not known how many of those had come in after the bombing. The percentage of fatalities and injuries probably closely paralleled that of the physicians but no accurate figures are available to support this supposition.

III. NATURE OF ATOMIC BOMB CASUALTIES

A. INTRODUCTION

1. Several groups studied the casualties caused by the atomic bombs in Hiroshima and Nagasaki. Shortly after the bombings, the Japanese Government sent medical groups from several of the larger universities to study the casualties in the two cities. These Japanese scientists gathered some data and a preliminary report of their findings was available when the United States forces landed in Japan. About this time, Gen. Guy Dewit, Chief Surgeon, GHQ, AF Pacific, directed Col. A. W. Oughterson to organize teams to survey the atomic bomb casualties. The Manhattan Project also sent a group under the direction of General Farrell, with Col. Stafford Warren as the Chief Medical Officer, to determine safety factors for the American troops and to make a rapid preliminary survey of the general effects of the atomic bombs.

On 8 September 1945, the group from the Manhattan Project and Colonel Oughterson first visited the two cities. As a result of their survey, it was decided that a large study group would be needed to obtain adequate data. In order to avoid duplication, Headquarters SCAP directed that the group from the Manhattan Project, the Army Medical Unit under Colonel Oughterson and a group of Japanese scientists appointed by the Imperial Government form "A Joint Commission for the Investigation of the Atomic Bomb in Japan." Colonel Oughterson headed this commission and set up plans for the study. About 20 medical officers and several enlisted men of the United States Army were assigned to the Commission. In addition, the Japanese sent members of the faculties and students from some of the larger universities to assist the Americans.

2. About the time the Joint Commission was being organized, the United States Navy directed the Naval Technical Mission, Japan 11, under Capt. Shields Warren to proceed to the areas to carry out similar observations. The Naval group and the Joint Commission reached the bombed cities in the latter part of September 1945. Though the two groups had no official connection, their respective leaders arranged that each group would be assigned certain phases of the study and that

they would ask permission of the Surgeons General of the Army and Navy to prepare a combined report.

3. The Joint Commission and the Naval group worked in the bombed areas for over 3 months, making detailed studies of the clinical material available, collecting pathological material, and gathering documents pertaining to the atomic bombing.

4. At the time the Medical Division of the Survey entered Japan the two groups were in the midst of their investigation. Since investigation along the same line by the Medical Division of Survey would have been needless repetition and since so little time was available, it was decided that no detailed study would be made by this group. Consequently, it was decided that the Medical Division would investigate the medical and sanitation aspects which were not being covered by the other groups and would look into the nature of the casualties only superficially. The Navy group and the Joint Commission cooperated with the Survey to the greatest extent and made all of their records available for examination. Much of the material presented in this report has been obtained from those two sources, and their cooperation was essential to gathering representative material in the short period of time available. It is the desire of the Medical Division of the Survey that they be given full credit for all of the information which has been obtained through them. It is understood that the Joint Commission and the Naval Technical Mission are preparing a combined report of the medical aspects of the atomic bombing which will be available in the near future.

5. The Medical Division has also consulted freely the report of the British Mission to Japan "An investigation of the Effects of the Atomic Bombs Dropped at Hiroshima and Nagasaki." The British report is a preliminary one and presents much of the information which previously had been obtained through the Joint Commission.

6. The medical aspects of the effects of the atomic bombs appear to be clear and concise even at this time. However, exact details relative to the distances the various effects extended, the duration of the effects, and other detailed informa-



Figure 27.—Joint Commission Clinic at Hiroshima Railroad Station. This is illustrative of the manner in which the various teams of the unit worked.

tion must await final analysis of the data for the combined report. The material presented herein must be considered preliminary and may be altered in some details by the final and complete study. It is felt, however, that it presents a summary of all the information available on the subject at this time. Generally speaking, the effects may be divided into three large groups:

(1) Secondary injuries, consisting of blast effects, secondary burns and injuries produced by falling and flying debris.

(2) Flash burns.

(3) Radiation effects.

Inasmuch as each of these categories seems to be quite distinct they will be discussed separately.

B. SECONDARY INJURIES

1. The blast effects of the atomic bombs as indicated by the effects on objects and persons in the target area are similar in most respects to those of other blast weapons. Examination of structures and clinical material indicates that the positive phase was probably longer than is usually seen in the high explosive blast, and that the negative phase was also of long duration. It is difficult or impossible to state the exact effect that the blast had on human life. There is evidence that the effects were considerable on structures and probably was responsible for many deaths near the center of the explosion. However, since the blast effects were combined with other effects such as primary and secondary burns, radiation effects, and the injuries produced by falling debris, the exact degree to which it influenced the number of deaths cannot be accurately stated.

2. One factor which must be considered in a study of the blast effects is that the bombs were aerial burst and even at ground zero a person or structure was some distance from the center of the explosion. It is well to remember, too, that near the center of the explosion the blast effects were downward. Toward the periphery of the effective zone the blast became more lateral in direction. It appears that few persons were thrown against buildings but that most of the blast effects resulted in casualties by collapsing buildings and flying missiles, especially glass. Apparently there were comparatively few instances of legs or arms being torn from the body by flying debris. It was reported in Nagasaki that there were evidences of overpressure in the shock wave. Large numbers

of the dead were said by survivors to have their abdomens ruptured and intestines protruding. Others were reported to have shown protruding eyes and tongues and to look as if they had been drowned. Such accounts were not obtained in Hiroshima. Genuine effects of overpressure seem to have been rare. Among the survivors there were a few cases of ruptured eardrums. Of 106 cases examined by the Japanese in Hiroshima on 11-12 August, only 3 showed ruptured eardrums. A study done in October at the Omura hospital revealed that only 2 of 92 cases from Nagasaki had ruptured eardrums and 3 other cases may have died. On the basis of the available information the British have estimated that the maximum pressure under the bomb probably did not reach two atmospheres. Most observers felt that true blast effects alone were rare and probably accounted for only a small percentage of the casualties.

3. The secondary burns probably accounted for a considerable number of the deaths in both Hiroshima and Nagasaki. Large numbers of structures were blown down upon people and shortly thereafter caught fire. The accounts of eye-witnesses who were in the area at the time attest to the large number of people who were injured and pinned beneath debris and finally succumbed to the effects of heat from the burning collapsed structures. In interviewing at a later date persons who showed burns it was felt that comparatively few of these were secondary burns. Most of the people who succumbed to secondary burns were injured otherwise or pinned beneath debris and therefore were unable to escape from the fires. There were a few instances of definite secondary burns which were minor among people who survived. It is probable that most of the people who acquired secondary burns were so disabled by other factors that the burns were responsible for their death. The fires particularly in Hiroshima apparently built up more slowly than has been encountered in cities that were subjected to heavy incendiary raids. This gave persons more time to escape from the damaged or demolished buildings. There are relatively few instances reported where people were able to escape from buildings and yet appeared to succumb to secondary burns. Large numbers of people who suffered other effects from the bomb tell of their escape through the demolished and partially burned city, but there were no reports of large numbers of people drop-

ping in the center of the streets either from the effects of heat or from the effects of carbon monoxide such as was seen in Tokyo, Osaka, or in the European cities. Some of the secondary burns in survivors apparently resulted from their efforts to extract members of their families or others from the collapsed and burning buildings. A few secondary burns resulted from primary flaming of clothing but many people reported such instances in which they were able to beat the fires out without sustaining burns of the underlying skin.

4. The injuries produced by falling and flying debris were apparently large in number. As one would naturally expect, the percentage and seriousness of such injuries was much greater near the center of the bomb explosion. It appears from interviews of survivors that the collapse of the buildings was sudden and that thousands of people were pinned beneath the debris. After varying periods of time many were able to extract themselves and many were extracted by the assistance of others. The nature of these injuries did not vary greatly from what one might expect. Large numbers of these people succumbed due to the fact that they could not be extracted from the debris. Though the Japanese houses are generally of light construction, they usually carry heavy roof timbers and heavy tile roofs. These characteristics probably played a considerable part in the large numbers of such casualties. Another feature of Japanese construction which caused many minor casualties was the extensive use of glass panels. Injuries by flying glass became more prominent at increasing distances from ground zero; as the more serious casualty-producing factors faded in the periphery, the number due to flying glass became increasingly significant (Fig. 28). It should be noted that though such injuries were frequent, they rarely resulted in death.

5. Available information indicates that secondary injuries occurred up to distances of 15,000 feet from ground zero. Japanese houses collapsed within a radius of about 7,000 feet at both Hiroshima and Nagasaki, but serious damage resulted in a much wider range. For instance, at Nagasaki the meteorological station which was located on an exposed hill at 16,000 feet had all of the windows broken on the near side and many of the window frames were broken and displaced. A large part of the roof was stripped of tiles. Many streetcars in Hiroshima suffered damage to glass

and overhead gear at distances up to 15,000 feet. It appears that secondary injuries, particularly those of lethal nature, began to fall off rapidly at distances beyond 7,000 feet, but that many of minor nature did occur up to 15,000 feet.

C. FLASH BURNS

1. The degree of the heat blast which followed shortly after the explosion of the atomic bombs in the two cities has not been accurately estimated. The British report reveals that considerable study of physical structures was done in an attempt to evaluate the amount of heat present at various distances from the center of the explosion. It is well known that the duration of the flash was extremely brief, probably a small fraction of a second and that the heat wave followed the observation of the flash of the exploding bomb. This point is emphasized by the fact that many people facing the blast were able to close their eyes before the heat wave reached them. Japanese claim that in some instances persons were able to shield their faces with their hands between the time the flash was seen and the time the heat wave reached them. The British report points out the roughening of polished granite which occurred in Hiroshima up to distances of 1,200 feet or more and in Nagasaki up to a distance of 1,800 feet or more from the ground zero. Japanese scientists investigating this problem have reported that this effect occurred up to 3,000 feet at Hiroshima and 5,000 feet at Nagasaki. Basing their estimation on the depth of roughening or spalling of the granite, the Japanese physicists have estimated a ground temperature at 1,500 feet from ground zero at Hiroshima to have exceeded $2,000^{\circ}\text{C}$. The British group were unable to concur in this figure and felt that it should be treated with reserve. In addition to the effects on polished granite other evidence of high temperature such as the bubbling of tiles was seen in both cities. The tile bubbles became progressively smaller at increasing distances from ground zero. On the basis of the study of the tile, Japanese geologists feel that the temperature necessary for such effects is near $2,000^{\circ}\text{C}$., with a minimum of $1,200^{\circ}\text{C}$., and that such phenomena occurred at distances beyond 2,000 feet in Nagasaki and beyond 1,500 feet in Hiroshima. They feel that these observations confirm their estimates based on the effect on polished granite. In addi-



Figure 28.—M. Y., 22 years old, male. Photo shows typical multiple lacerations due to flying glass fragments.

tion to the effects on polished granite and tiles, there were effects on other objects such as road surfaces, treated and untreated timbers, fabrics and human skin which aided in estimating the degree of heat present at various distances from ground zero. Instances of spontaneous flaming of clothing were reported to have occurred beyond 6,000 feet. Scorching of telegraph poles disappeared at roughly 9,000 feet in Hiroshima and 10,000 feet in Nagasaki. It thus appears that the heat wave following the explosion of the atomic bomb extended over a large area and that it reached great intensity within a radius of 3,000-4,000 feet. Exact figures cannot be given at this time but more detailed study may in time clarify this point.

2. Another interesting and significant feature of the heat wave was shadows cast by intervening objects which protected otherwise exposed surfaces from the direct heat radiation. All intervening structures were successful in shielding objects and on occasion clumps of grass or the leaf of a tree was seen to offer some protection before they withered or burned. Due to the size of the radiating fire ball narrow objects were found to cast shadows smaller than themselves and with gradient edges. This feature will be elaborated upon later in discussing the flash burns of human skin.

3. The effect upon fabrics was particularly interesting. Material which was examined in Hiroshima showed clearly the difference in the absorption of heat between dark colored fabrics and lighter colored ones. For instance, a white cotton blouse which was examined had pale pink sleeves upon which was superimposed print green leaves and red flowers. Over one shoulder of the garment the red and green colored areas were burned out and over a larger surrounding area the colored portions were partially burned. The white, however, remained intact. In a shirt of alternating dark and light grey stripes about one-eighth inch wide the dark stripes completely burned out but the light stripes scorched only slightly. A white dress with blue polka dots showed the dots to be charred over a large area while the white remained unchanged. A kimono with white lozenges on a blue background showed large areas which were burned. It was said to have been fired directly and had to be beaten out. On the edges of the burned area the white figures had survived but the blue was charred. It was generally recognized by the Japanese in the two cities that persons

were more likely to be burned at the same distance from the bomb explosion if they were wearing black or dark colored clothing. The British report a piece of Japanese paper on which characters were written in black ink and the characters had been burned out at a distance of 7,500 feet. They also obtained reports but did not see evidence that red ink survived where black ink was burned out. The influence of the nature of the coloring matter cannot be entirely ruled out, but it is felt that the absorption of radiant heat due to the color itself was the prime factor in this differential destruction of various colored garments.

4. The effect of the flash upon the human skin was seen to be comparable in Hiroshima and Nagasaki. Survivors in the two cities stated that people who were in the open directly under the explosion of the bomb were so severely burned that the skin was charred dark brown or black and that they died within a few minutes or hours. The Joint Commission's preliminary observations indicate that burns of unprotected skin occurred at distances of 12,000 to 13,000 feet from the center of the explosion. Third degree burns occurred up to 4,500 feet and some such burns were reported up to 7,200 feet. Many persons reported having felt a heat blast at distances as far as 24,000 feet from ground zero, but were not burned. The degree of the burn of unprotected skin naturally varied inversely with the distance from the center of explosion. Flash burns as seen were largely confined to the exposed areas of the body but occasionally they had occurred through varying thicknesses of clothing. Many illustrations of this were seen (Figs. 29-34). Generally speaking, the thicker the clothing was the more likely it was to give complete protection against flash burns. For instance, one was seen who was burned over the shoulder except for a T-shaped area about one-fourth inch in breadth which remained unburned. When the garment she was wearing at the time was studied, it was seen that the T-shaped area corresponded to an increased thickness of the clothing due to the seam at the insertion of the sleeve and across the shoulder to the neck line (Fig. 35). Several people were seen who were burned through a single thickness of kimono but a broad band extending down each side of the garment which corresponded to the increased thickness due to the lapel was unburned or less severely burned (Fig. 36). There were many instances where skin was burned beneath



Figure 29.—T. Y., 18 years old, male dressed in knee-length trousers and walking away from blast. Third degree burns.



Figure 30.—T. Y., 35 years old, male. Prone in open, 5,600 feet from ground zero, bare from waist up, blast from direction of feet. Note sharp line of demarcation of healing flash burns. Protected area on neck is due to folding of skin resulting from extension of neck.



Figure 31.—S. S., 27 years old, male. Flash burns of back, arm, hand, face, and neck., Note irregular outline of burned areas with more severe burns on exposed surfaces.



Figure 32.—J. H., 53 years old, male. Sitting in Japanese house before open window at 6,000 feet. Note sharp line of demarcation of healed flash burns on exposed surfaces.



Figure 33.—M. M., 22 years old, male. Standing 6 feet from open window at 4,000 feet from center of blast. Shows shirt which was worn at time of explosion and was not scorched.



Figure 34.—Same patient as figure 33. Note scars of healed flash burns of shoulder and back and sharp line of more severe burns on exposed surfaces. Shirt was not scorched.



Figure 35.—S. T., 49 years old, female. Note pigmentation of healed flash burns. T-shaped area of protection on left shoulder was due to increased thickness of clothing at seam of insertion of sleeve and across shoulder to neck.



Figure 36.—H. K., 33 years old, male. Photo shows severe burns of exposed surfaces and some burns of trunk through kimono. Note protection of skin of left chest due to increased thickness of clothing at lapel of kimono.

tightly fitted clothing, but was unburned beneath loosely fitted portions (Figs. 37 and 38). The strap of a pair of Japanese shoes was seen to protect a portion of the foot which it covered while the surrounding skin area was seriously burned (Fig. 39). In addition to garments, it was apparent that other shielding factors also protected against the flash burns. It is reported that the burned areas of the skin showed objective and subjective evidence of burns almost immediately after the explosion. At first there was marked erythema and then, depending upon the degree of burning, other evidence of thermal burns appeared within the next few minutes to hours. The sharp line of demarcation of burned areas as determined by clothing is demonstrated in several figures. It is also interesting to note that the heat wave came in a direct line and that the area burned corresponded sharply to this directional thrust. Persons whose sides were towards the explosion often showed definite burns of both sides of the back yet the depressed area over the region of the spine escaped burning (Figs. 40 and 41). Concrete buildings and Japanese houses apparently afforded complete protection against such burns providing one was not near a window. One instance was seen in which a man was writing before a window and his hands were seriously burned. However, the exposed face and neck received only slight burns due to the angle of entry of the heat wave through the window and the fact that the face and neck were not so directly exposed (Fig. 42). In other instances persons standing behind narrow structures which shielded a portion of their bodies were not burned over the shielded areas, yet the adjacent unshielded portions of the skin were burned.

5. The Civilian Defense Division of the Survey has accumulated some data relative to burns of persons in tunnel air-raid shelters in Nagasaki at the time of the bombing. According to this information, some of the burned individuals had been at considerable distance from the tunnel entrance (up to 300 feet) and others were partially hidden by baffle walls or curving tunnel walls. Some of the baffles were blown into the tunnel entrances by the bomb blast. The entrances generally were very near ground zero though some were as far as 2,400 feet; some entrances did not even face in the direction

of the bomb blast. No one located in lateral projections of the tunnels was reported to have been burned. It was reported that the burns were largely on the exposed surfaces and in general presented characteristics suggestive of flash burns. Details are set forth in the Civilian Defense Division report of the Survey. The general concept of flash burns resulting from atomic bombs is that they are due to radiant heat. Since the heat is radiant it must pass in a straight line and is obstructed by intervening objects. There may be reflection from surfaces but in being reflected the intensity of the rays is decreased considerably (probably 10 times or more). The degree of reflection depends largely upon the reflecting surface, and with each subsequent reflection there is a further decrease in intensity.

6. Physicists consulted about the burns in the Nagasaki tunnels did not believe that such burns could be explained on the basis of convected heat (a blast of hot air) even immediately beneath the bomb. It was their opinion that heat of sufficient intensity to burn human skin at ground level probably could be attributed only to radiant heat.

7. In studying the data on these cases, however, it is difficult to understand how the burns could have been caused by radiant heat. In the first place, the baffle walls would have remained intact until the radiant heat subsided and until the arrival of the blast pressure wave. This fact often was illustrated in both Hiroshima and Nagasaki, when objects such as leaves, posts, etc., had cast a protective shadow on some surface shortly before they were blown away by the blast. Secondly, the location of some of the tunnel entrances with respect to the bomb blast seems to render an explanation based on reflected radiant heat difficult to understand. Nevertheless, reflection of heat waves cannot be ignored entirely.

8. Col. A. W. Oughterson of the Joint Commission stated that a member of his group had investigated this question quite thoroughly. He interrogated many persons and actually accompanied some of them to the tunnels and had them show their exact location at the time of the bomb burst. He reported that in every instance the individuals were in tunnels with entrances facing the explosion and were near enough to the entrance to have been burned by radiant heat.

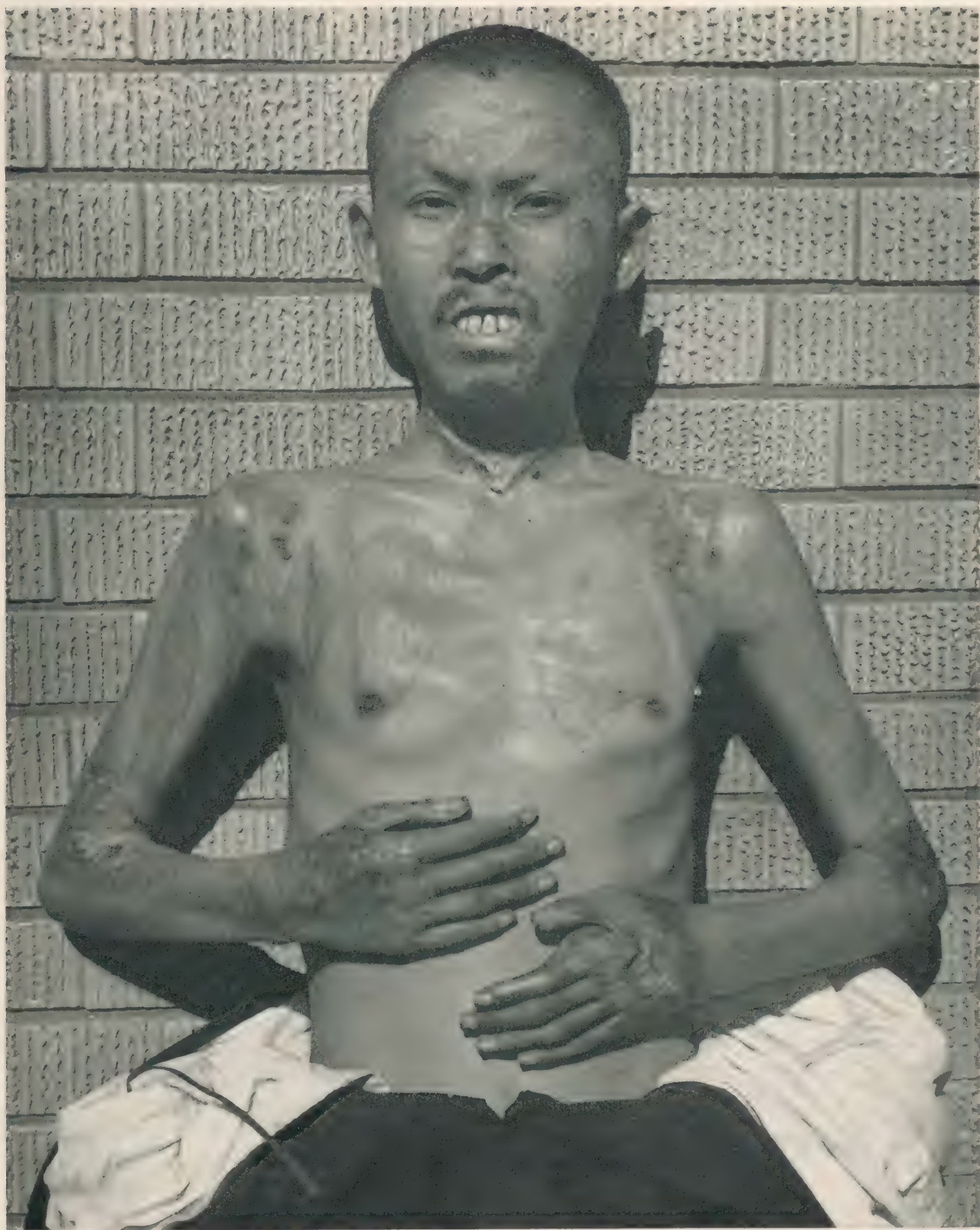


Figure 37.—T. K., 34 years old, male. In open facing blast, wearing white shirt, blue coat and trousers. No change in shirt but coat and trousers charred. Severe flash burns and recovering from radiation sickness.



Figure 38.—Y. T., 19 years old, male. Photo shows localized alopecia in burned area below line of cap with no burns above and no generalized epilation. Note sharp line of protection of collar and severe burning of shoulder and trunk through shirt.



Figure 39.—M. I., 19 years old, female. Flash burns of feet, blast from right. Note area of unburned skin at base of great toe on left foot due to protection of Japanese sandal strap.



Figure 40.—S. N., 37 years old, male. Was working in open at 5,500 feet from center of blast, wearing trousers but bare above waist. Blast came from right. Note area of protection over spine due to shielding by right side of back.



Figure 41.—Same patient as Figure 40. Flash burn. Note protection of under surface of arm and lateral thorax by position of arm at side.



Figure 42.—T. O., 55 years old, male. Was sitting before open window in position shown at 6,000 feet, wearing long sleeved kimono. Due to direction of blast he received severe burns of exposed hands but only first degree burn of exposed face and neck.

9. Although information does not coincide with that collected by the Civilian Defense Division, it is possible that complete analysis of all the data which have been collected by the Joint Commission may shed some light on this subject.

10. The Joint Commission studied a group of 580 workmen in Hiroshima who were marching across the Koi Bridge facing the bomb at a distance of 7,500 feet. All were burned with the exception of three at the rear who were protected by the eaves of a building. Another instance of the degree of protection afforded by certain structures is shown in the following example. A large group of workmen were in the street and were so placed that some of them were behind a one-story Japanese building and others were behind a two-story Japanese building. There were no burns among the group behind the two-story building, but all of those who were apparently partially protected by the one-story building received burns.

11. It was reported by the Japanese physicians who attended many of the burned cases, and it was also the impression of all who subsequently observed these burns, that they healed promptly and did not show any unusual clinical features. Our group felt on observing many of these burns that there might be an increased tendency to the formation of keloid in the healing. Questioning of many Japanese physicians resulted in their uniform opinion that the tendency to keloid was no greater from these burns than from other thermal burns. It was explained that the large degree of secondary infection which followed in most cases and resulted in delayed healing may have been responsible for the excess scar tissue formation which was rather frequently seen. At the time the Medical Division visited the area, 3 months after the explosion of the bomb, many of the burns were still unhealed. There were a few instances of burns healing with contractures and limitations of mobility of certain joints. A typical example of this is shown in Figure 43 which shows sharp limitation of motion of the elbows of a Japanese boy. Japanese physicians in the area stated that often the primary burns of minor nature were completely healed before patients subsequently developed evidence of radiation effects.

D. RADIATION EFFECTS

The radioactivity of the atomic bombs is well shown in the effects upon survivors. The manner by which radiation effects of the bombs could be transmitted to man are listed below and the evidence concerning each is briefly submitted.

1. *Primary fission products* deposited directly in the area shortly after the bomb exploded.—The soil at both Hiroshima and Nagasaki has been examined at frequent intervals for evidence of radioactivity. The first studies were made by the Japanese using a Lauritsen electroscope and then by American scientists using Geiger counters. At Hiroshima activity has been greatest at the center with other active areas near the Koi bridge and further west of the bridge. At Nagasaki the greatest activity is in the hills northeast of the center of the explosion. The higher counts of radioactivity in these areas is felt to be due to direct deposits of fission products. Both areas lie downwind from the center of the explosion and at Hiroshima, Japanese physicists have found known fission products (in the barium, lanthanum and strontium fractions) in deposits in these areas. This further supports the idea of direct deposition rather than induced radioactivity. The important point from the medical standpoint is that the degree of activity in these areas is not sufficient to produce casualties.

2. *Induced Radioactivity* caused by the interaction of neutrons with matter.—As stated above there is no evidence of significant induced radioactivity in the soil of the two cities. One patient, a young Japanese male, was seen in the Kyoto Imperial University hospital who did show what may have been an effect of induced radioactivity. He had been in Nagasaki at the time of the bombing, about 5,500 feet from the center of the explosion. Although he appeared to remain well for a period following the explosion, during this time he carried in his watch pocket on the right an iron key and in his left side pocket a metal (probably aluminum) cigarette case both of which he had been carrying at the time of the bomb burst. At the end of about 3 weeks he first began to feel ill and subsequently showed the rather typical findings of radiation sickness with epilation of the scalp and leucopenia. He also developed burns in the region of both groins which roughly corresponded in size and position to the key and the



Figure 43.—H. T., 15 years old, male. Was naked above waist, in open at 5,250 feet, watching United States planes. Note partially healed flash burns with excess granulation tissue and contractures of both elbows.



Figure 44.—Healed burns in both groins which apparently resulted from induced radioactivity of an iron key in right watch pocket and aluminum cigarette case in left side pocket.

cigarette case (Fig. 44). He subsequently recovered but typical pigmented scars remained at the site of the burns which had healed slowly. It was reported by his physician in Kyoto that the cigarette case showed radioactivity as determined by exposure of X-ray film at the end of 2 months, but in 3 months had lost the activity. The key was not tested. Certainly the general effects can not be interpreted to be the result of radioactivity from the two metal objects, but it seems clear that the objects were probably responsible for the skin burns. No other cases suggesting the effects of induced radioactivity of matter sufficient to produce clinical effects could be found by any of the groups working in either city. Japanese scientists have found the phosphorus in the bones of human victims to be radioactive. This phenomenon can be attributed only to neutrons. However, the effect of total body radiation with neutrons is not well known and may differ in other ways from the effect of gamma rays. Thus the contribution neutrons may have made to other observed biological effects cannot be estimated.

3. *Gamma rays* including neutrons and other penetrating radiation liberated by the fission process and produced as a part of the total spectrum of energy.—The term gamma rays here is used in a general sense and includes all penetrating radiations and neutrons that caused injury. No attempt has been made to distinguish other types of radiation which may have contributed to the injurious effects. A great deal of the information presented herein was taken from a study of the records of the Joint Commission. For details of this study one should see the complete report to be published by the Commission. Since the Allies had no observers in the area for the first few weeks after the bomb explosion, the information relative to the effects during this period has necessarily been gathered second hand and is not based on primary observation by our scientists. It seems, however, that a fairly clear-cut picture has been obtained through study of the material from many sources.

(a) *Clinical picture*.—In general the gamma rays were very penetrating. There were no skin lesions which could be directly attributed to gamma rays even in those patients showing severe radiation disease. The Japanese stated that those individuals who were very near the center of the explosion but did not suffer from flash burns or

secondary injuries, became ill within 2 or 3 days. Hemorrhagic diarrhea followed and they expired quite quickly. Some died within 2 or 3 days after the onset and most of them within a week. The Japanese reported that it was difficult to demonstrate the remarkable changes in the blood picture of those dying so rapidly. Upper respiratory and gastro-intestinal mucous membranes showed acute inflammation.

The larger portion of the radiation cases which had been at greater distances did not show severe symptoms until 1 to 4 weeks after the explosion. Many felt weak and listless on the day following the bomb burst. Nausea and vomiting appears also to have been frequent at this time. Within a day or two the appetite improved and the person felt quite well until symptoms appeared at a later date. It is the opinion of some of the Japanese physicians that those who rested and subjected themselves to less physical exertion showed a longer delay before the onset of subsequent symptoms. After this period during which the individuals usually felt perfectly well, they began to note lassitude, malaise and anorexia. Within 12 to 48 hours fever became evident. In many instances it reached only 39° C. and remained for only a few days (Fig. 45). With the subsidence of fever the patients usually showed a rapid disappearance of other symptoms and soon regained their feeling of good health. The degree of fever apparently had a direct relationship to the degree of exposure to radiation. In many other cases the temperature was quite high reaching 40° to 41° C. The fever once developed was usually well sustained and in those cases terminating fatally it continued high until the end (Fig. 46). Other manifestations which were commonly seen were leucopenia, epilation, inflammation and necrosis of the gums, stomatitis, pharyngitis, petechiae and evidence of ulceration of the lower gastro-intestinal tract.

Leucopenia appears to have been a constant accompaniment of radiation disease. It is believed that leucopenia existed in some of the milder cases without other evidence of radiation effects. It is also thought that the degree of leucopenia was probably the most accurate index of the amount of radiation the person received. The white blood count in the more severe cases ranged from 1,500 to 0 with a complete absence of neutrophils. The moderately severe cases showed total white blood

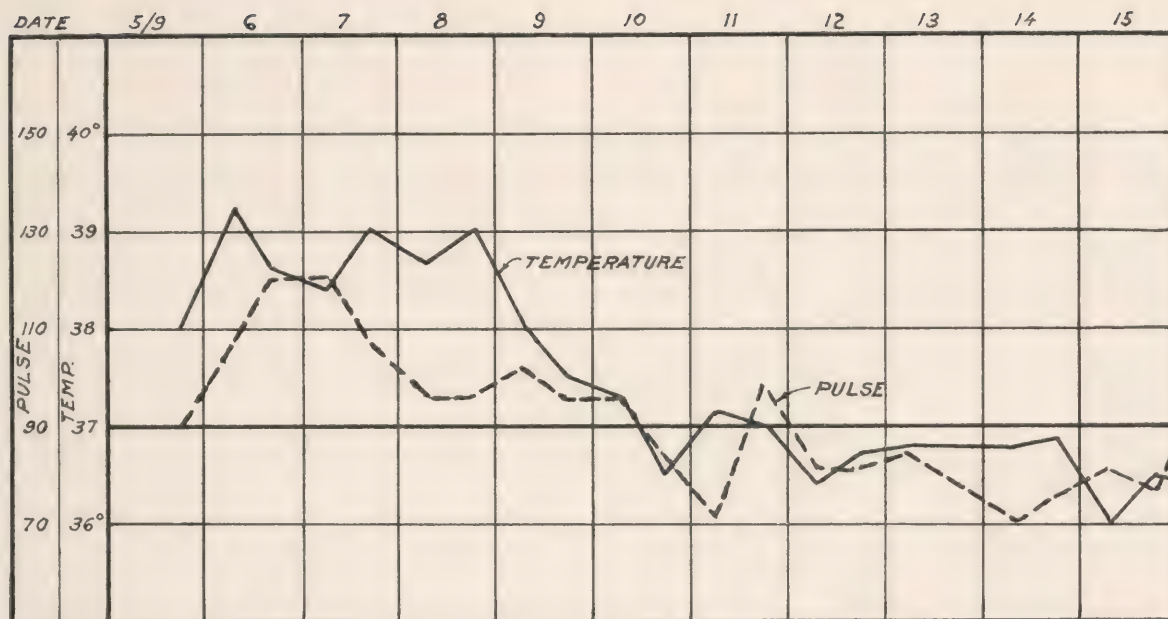


Figure 45—Clinical summary of case recovering from radiation disease (Hiroshima) Sumiko Kanekuni, Age, 24 years; Sex, Female; Occupation, None

Clinical Findings

History.—Was in Japanese house 1,200 meters from center of blast, knocked unconscious by falling ceiling. Remained well until about 1 September when noted weakness, malaise, and soreness of gums. Generalized epilation of scalp had begun on 16 August. Pharyngitis on 3 September, generalized petechiae 4 September. Bloody diarrhea 5 September only.

Physical Examination.—Epilation of scalp, necrotic gingivitis, exudative pharyngitis bilateral, generalized petechiae, fever and pallor.

Laboratory Findings:

5 Sept.	—RBC 2.43—Hbg. 28%—WBC 480	
6 Sept.	----	450 bleeding T 30', clot T 3'30"
7 Sept.	----	320 stool occ. blood-0, urine alb±
9 Sept.	----	240 urobilin 0
10 Sept.	----	170 urobilinogen 0
11 Sept.	1.76 35	240
13 Sept.	----	980
14 Sept.	2.11 40	1860
15 Sept.	----	2260
17 Sept.	----	3400 Sed. rate 52 (Westergren)
18 Sept.	2.40 45	3840
26 Sept.	3.07 56	4740 Eos 1, Juv 3, stab 14, seg 50, lym 28, M 4

Diagnosis.—Radiation disease manifest by: 1. Epilation, 2. anemia, 3. leukopenia, 4. purpura, 5. stomatitis, 6. pharyngitis.

Treatment.—Ultraviolet irradiation, liver & arsenic p. o. autotransfusion.

Recovery.—Discharged from hospital 28 September 1945.

(Courtesy Joint Commission for Investigation of the Atomic Bomb in Japan.)

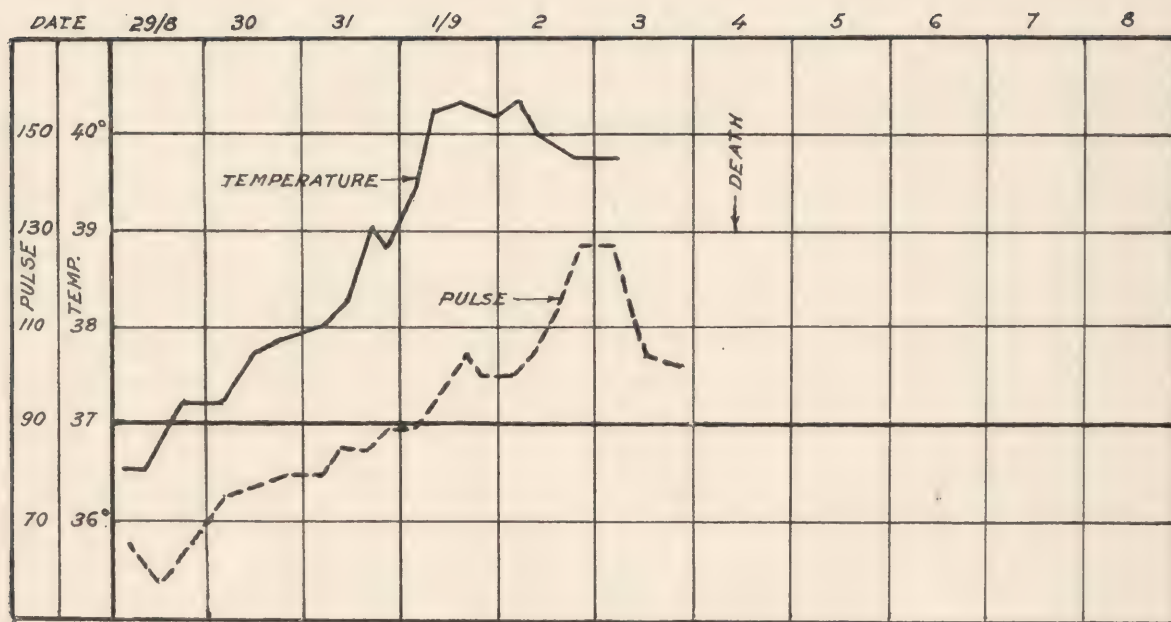


Figure 46.—Clinical summary of case dying of radiation disease (Hiroshima), Tetsumi Motoyama; age, unknown; sex, Male; occupation, soldier.

Clinical Findings

History.—Patient admitted 29 August in delirious state, adequate history not obtainable.

Physical Examination.—Delirium, petechiae over skin and mucous membranes, gingivitis and mild epilation of scalp.

Laboratory Findings.—4 September: RBC 2.62 M, Hbg. 61%, WBC 300, diff count of 25 cells: 20 lymphocytes, 4 neutrophils, 1 monocyte. Bone marrow showed hypoplasia.

Diagnosis.—Radiation disease manifest by: 1. Gingivitis, 2. purpura, 3. epilation, 4. anemia, 5. leucopenia, 6. hypoplasia of bone marrow.

Treatment.—Autotransfusion 20 cc.

Died.—4 September 1945. Autopsy was obtained.

(Courtesy of Joint Commission for Investigation of the Atomic Bomb in Japan)

counts of 1,500 to 3,000 with a neutropenia, and the bone marrow showed evidence of degeneration. The milder cases showed WBC counts of 3,000 to 4,000 with minor degenerative changes in the bone marrow. The changes in the erythropoietic system were usually not as startling but corresponded roughly to the deficiency of white blood cell formation. Blood platelet formation also was reported to be affected.

Epilation usually began about 2 weeks after the bomb explosion, though in a few instances it is reported to have begun as early as 4 to 5 days after the exposures. The areas involved were affected usually in the following order depending upon the degree of exposure to radiation: scalp, axilla, beard, pubic region and eyebrows. The involvement of the scalp was usually uniform and rarely resulted in complete baldness (Figs. 47 and 48). Microscopic section of the involved areas has shown atrophy of the hair follicles. An interesting feature of the epilation which has been reported by the Japanese and has not been confirmed, is that it appeared to be less marked in persons with grey hair than in persons with dark hair even though the exposure was the same. In those patients who survived 2 months, evidence of regeneration of the hair was present almost without exception.

Ulceration of the gastro-intestinal tract, including gingivitis (Fig. 49), stomatitis and pharyngitis, was common in the more severe cases. The clinical picture seen in these cases is essentially the same as that seen in leucopenias due to other causes. Bloody diarrhea was commonly seen but in many instances was difficult to evaluate because of the possibility of its having been on an infectious basis. Petechiae occasionally appeared in the mucous membranes about the time of the onset of the gingivitis. However, those hemorrhages appearing in the skin were often more delayed.

Autopsy findings on those cases dying of radiation effects have been reported to have shown typical findings which are known to exist in cases dying with agranulocytosis. Petechial hemorrhages of the viscera, inflammation and necrosis of the gums, mouth, pharynx, stomach, and intestines have been common findings. Occasional focal necrosis of the liver has been encountered. No massive hemorrhages into the skin or other structures have been reported. A large percentage of the cases has been found to have died of secondary

diseases such as septic broncho-pneumonia, pneumonia with early abscess formation and pyothorax, and tuberculosis. Section of the testes is reported to have shown "spermatogenesis to be poor." Records of microscopic examination of ovaries have not been reported. Deaths from radiation began about a week after exposure and reached a peak in 3 to 4 weeks. They had practically ceased to occur after 7 to 8 weeks.

b. Radius of effect of gamma rays.—A preliminary evaluation of the data collected at Hiroshima has revealed that most of the cases occurred within a radius of 5,000 feet of the blast. An example is seen in 2 groups of workmen who were in the open at 3,600 feet but were screened by a wooden building. There was a total of 198 of whom 6 were killed by debris, of the remaining 192, 95 subsequently died from the effects of radiation. Other groups at similar distances in the open also showed a comparable mortality rate. It appears that radiation killed nearly everyone who was fully exposed to the gamma rays but was protected from other forms of death at all ranges up to 3,000 feet. Beyond 3,000 feet the effects of radiation were mild or absent. Some cases showed epilation at distances up to 7,500 feet and some mild effects may have extended to 9,000–10,000 feet in certain instances.

c. Shielding from gamma rays.—The Joint Commission has gathered a great deal of information for study relative to the shielding effect of various types of buildings. Their information has not yet been subjected to complete analysis, but a few general facts have stood out significantly. For detailed information on this subject one is referred to the combined report when it becomes available. In the meantime the following material is presented as impressions of that group as well as others who visited the area.

Clothing and fairly substantial wooden buildings did not offer any appreciable protection against gamma radiation. The only structures that appeared to have any shielding value against gamma rays were substantial reinforced-concrete buildings and even in these the protection appeared only partial unless shielded by several floors.

Earth was effective in protecting, provided it was present in sufficient thickness. Persons in Nagasaki were protected from gamma rays even close to ground zero when they were behind hills or in air raid shelters dug into the side of hills or

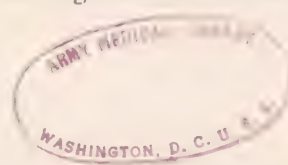




Figure 47.—K. N., 9 years old, male. Standing in open 2,300 feet from blast. Patient suffered lacerations and radiation sickness. Photo shows generalized epilation.



Figure 48.—S. Y., 19 years old, female. Sitting on second floor of 3-story concrete building, 2,625 feet from center of blast. Patient suffered radiation sickness. Photo shows generalized epilation.



Figure 49.—S. I., 38 years old, male. Recovering from radiation sickness. Photo taken 3 months after bombing shows necrosis of gum and underlying mandible.

embankments. A few examples gathered by the Hiroshima unit of the Joint Commission may be cited:

(1) The Bankers Club, which is located 700 feet from ground zero is a 3-story, strong building of reinforced concrete with a tile roof. There was no serious damage to the main structure of the building by the blast. Of 23 people known to be in the building at the time of the explosion, 20 had secondary injuries and 17 had burns but none were killed immediately. Twenty-one of the 23 died between 12 and 23 August—all believed to have been due to radiation effects. The only 2 survivors were on the ground floor where they were probably shielded by all floors and possibly by adjacent buildings.

(2) The Communications Building of the Chugoku Army Headquarters is a partly underground concrete structure located 2,300 feet from ground zero. The occupants were shielded by 12 inches of concrete and 3 feet of earth. There were no cases of radiation disease among the 26 or more occupants.

(3) The Chugoku Electric Building is a 5-story building of reinforced concrete located 2,100 feet from ground zero. There were casualties due to radiation on all floors on the side near the bomb; many others on the fifth and fourth floors and a few on the third floor. Those people on the first and second floors away from the bomb blast and shielded by the upper floors showed no radiation disease.

(4) The City Hall which is about 5,000 feet from ground zero showed only six possible mild cases of radiation disease.

4. *Effects on reproduction.*—The Joint Commission has investigated this problem in relation to the effects of radiation. Here, too, the final data is not complete but a few impressions may be stated.

All or nearly all pregnant women in various stages of pregnancy who survived and who had been within 3,000 feet of the center of the explosion have had miscarriages. Even up to 6,500 feet they have had miscarriages or premature infants who died shortly after birth.

In the group of pregnant women between 6,500 and 10,000 feet who could be traced, about one-third have given birth to apparently normal children. The remainder had not reached the term

of their pregnancy or their pregnancy had terminated prematurely. No definite effects attributable to the bomb have been seen in these women. Records of the Hiroshima Prefectural Health Department revealed that 2 months after the explosion of the bomb the incidence of miscarriages, abortions and premature births for the entire city, without consideration of whether the women were even in the city at the time of the bombing, was 27 percent as compared with a rate of about 6 percent prior to the bombing. Other factors such as malnutrition, emotional disturbances and poor living conditions may play a large part in this increase. As a matter of fact, there is no concrete evidence upon which one can say that radiation alone played any definite part.

Amenorrhea has been a common finding throughout Japan, especially during the last 2 years. There appears to have been an increase in the atomic-bomb areas and from the other clinical effects there is no doubt but that radiation had been responsible for many cases in Hiroshima and Nagasaki. An accurate evaluation, however, has been impossible in view of the many factors which might contribute to this condition.

Sperm counts done in Hiroshima by the Joint Commission have revealed low sperm counts or complete aspermia for as long as 3 months afterwards in males who were within 5,000 feet of the center of the explosion. Effects on spermatogenesis have also been evident among cases dying of radiation effects. The radius of effect is probably greater than 5,000 feet but this has not been accurately determined at this time. Sections of ovaries from autopsied radiation victims are also being studied. A period of years will be required to learn the ultimate effects of mass radiation upon reproduction.

E. RELATIVE IMPORTANCE OF VARIOUS TYPES OF INJURIES

1. There are no records available relative to the cause of death of those who died immediately after the bomb explosion. No doubt many of them theoretically died many times over in that a single person may have been subjected to several injuries any one of which alone would have been fatal. It is expected that radiation would not produce immediate death, thus these deaths must be attributed to the other injurious agents. The Hiroshima Prefectural Health Department estimated that 60 percent were due to burns (flash or

flame), 30 percent to falling debris, and 10 percent to other injuries. Others have estimated that 50 percent resulted from burns and 50 percent to other mechanical injuries. It is impossible to be more exact in the absence of more information, but both of these sets of figures are probably somewhere near the true proportions.

2. Of those victims who died at a later date there were no doubt increasing numbers who succumbed to radiation effects. Table 1 shows an analysis of the records of 1,080 patients seen in hospital and out-patient clinics in Hiroshima. This table shows the high incidence of radiation sickness among casualties within the first 3,200 feet and the progressive decrease in incidence at greater distance.

TABLE 1.—Analysis of 1,080 cases at Hiroshima showing percentage of radiation effects at various distances from bomb

Distance, feet	Total cases	Cases showing definite radiation effects		Cases showing no radiation effect	
		Number cases	Percent	Number cases	Percent
0-1,640	73	69	94	4	6
1,640-3,281	339	323	95	16	5
3,281-4,921	262	128	49	134	51
4,921-6,562	278	68	24	210	76
6,562-8,202	97	26	27	71	73
8,202-9,743	31	12	39	19	61

3. An analysis of 381 cases at Nagasaki relative to the type of injuries received is shown in Table 2.

TABLE 2.—Analysis of 381 cases at Nagasaki showing the percentage of various injuries at various distances from explosion

Distance (feet)	Total cases	Percent of patients showing—				
		Radiation epilation	Radiation sickness	Flash burns	Flame burns	Secondary injuries
0-3,281	116	28	39	22	9	62
3,281-6,562	215	36	41	52	9	50
6,562-9,743	50	12	16	44	18	26

It will be noted that the percentages total more than 100 because many patients had multiple injuries. The low incidence of radiation sickness and epilation within the first kilometer (3,281 feet) is surprising in view of the experiences in Hiroshima and general impressions elsewhere. It must be remembered, however, that for one to survive at such close proximity indicates a great deal of protection.

4. It appears from all the information availa-

ble at this time that radiation effects were very prominent within a radius of 6,500 feet and were almost uniformly present within 3,250 feet, except where an unusual amount of shielding was present. Beyond 6,500 feet radiation effects appeared to drop off very sharply. Flash burns were protected by clothing and buildings within less than 3,250 feet from the blast. Flame burns and other secondary injuries remain fairly prominent up to 13,500 feet. It is probable that this was due to the decreasing incidence of other injuries at greater distances and also that these injured persons were more frequently seen since their injuries were rarely fatal.

5. The importance of radiation as a cause of death is definitely underrated by the foregoing presentation. Few persons within one-half mile of ground zero died of radiation disease because so many suffered other types of deaths before they had lived long enough to show radiation effects. In other words, survival within this radius (despite the blast effects, flame, and flash burns) indicates a large amount of protection. There is reason to believe that if the effects of blast and fire had been entirely absent from the bombing, the number of deaths among people within a half mile radius would have been almost as great and the deaths among those within a 1 mile radius would have been only slightly less. The principal difference would have been in the time of the deaths. Instead of being killed outright as were most of these people, they would have survived for a few days to 3 or 4 weeks, only to die of radiation disease.

6. There is some reason for postulating this point, for it was shown in Hiroshima and Nagasaki that because a structure protects against the blast, flame and flash effects of the atomic bomb does not mean that it will protect against radiation effects. Otherwise few would have died from the effects of the gamma rays. Actually, there were thousands who died of radiation, though the exact number will never be known. Colonel Stafford Warren, in his testimony before the Senate Committee on Atomic Energy, estimated that radiation was responsible for 7.8 percent of the total deaths in the 2 cities. Most medical investigators who spent some time in the areas feel that this estimate is far too low. It is generally felt that no less than 15 to 20 percent of the deaths were from radiation. In addition there was an equal number that were casualties but survived, as well as countless thousands who probably were affected

by the gamma rays but not to a sufficient extent to produce definite illness.

7. An estimate of the importance of the various causes of death is as follows:

	Percent
a. Radiation disease.....	15-20
b. Flash burns.....	20-30
c. Secondary injuries.....	50-60

8. Again one must point out that the above estimates are based on incomplete study and that for final analysis one should consult the combined report when it becomes available.

F. TREATMENT

1. As mentioned previously, the treatment of the bomb casualties was slow and inadequate. The Japanese got some medical teams into the areas within a few days but made no significant progress in this direction for over a week. Even when the teams arrived they could do little as their supplies and facilities were extremely limited. There was no whole blood or plasma and only a negligible quantity of many important drugs. The treatment furnished probably did not have any significant effect on the mortality rate.

2. Many cases could have been saved if facilities, supplies, and personnel had been adequate shortly after the bombing, although probably the deaths from true blast effects, flame burns, or serious injuries due to collapsing structures would not have been altered appreciably. Generally speaking, these cases died almost immediately or else survived. Many of the flash burn cases could have been saved with tremendous quantities of plasma and parenteral fluids if treatment had begun within a few hours after the bombing. Probably the most significant results could have been achieved with the radiation cases. With large quantities of whole blood and adequate supportive treatment possibly 10 to 20 percent of those dying of radiation might have survived. However, it is doubtful that 10 percent of all the deaths resulting from the atomic bombs could have been saved with the best medical care; 5 to 8 percent is probably a more likely figure.

3. It should be noted that the American medical groups did not conduct any studies of the treatment of the atomic bomb victims. As mentioned previously the American teams were not in the areas until the last 7 to 10 days of September and by this time the occurrence of deaths from bomb effects had almost ceased. Further, in

order to be free for the investigative work, and in order that there would be a clear understanding of responsibilities, and because of the lack of personnel, the arrangement with the Japanese was that the Americans would not treat any cases. The Japanese had sole responsibility for treating bomb victims, though the American forces did provide some medical supplies and often consulted with the Japanese relative to treatment methods.

G. NUMBER OF CASUALTIES

1. *Hiroshima*

The number of casualties has been variously estimated by many persons who have studied the situation. It is clear that no accurate counts were made and that the best one can hope for is a close approximation. The assistant director of the Hiroshima Red Cross Hospital estimated that 70,000 were killed outright, that 50,000-60,000 died within the next 2 months and that only about 6,000 of the city's population remained uninjured. Col. John R. Hall, Jr., X Corps Surgeon, has recently estimated that 47,000 died immediately, 15,000-17,000 are missing and about 60,000 have died since the bombing from various causes.

The Joint Commission in a study of the over-all death rates at various distances from the bomb, has studied a large number of school children. These children were organized into work groups and were distributed about the city doing a variety of war jobs. Very few were actually in school at the time the bomb fell. A study of these groups (Table 3) gives some approximation of the mortality at certain distances. The term "Missing (Unknown)" indicates that the child's parents did not know what had become of it. "Untraced (Disconnected)" means that no member of the family could be contacted. The computed deaths is then based upon the assumption that all of the "missing" were killed and that the "untraced" suffered the same fate as the remainder at that distance.

On the basis of the above mortality rates the British have applied these figures to an estimate of the population distribution by the Japanese census office and have arrived at a mortality figure most likely between

70,000 and 90,000 persons. They further estimate that an additional 100,000 were injured. The death figures coincided very closely with those arrived at by the Naval Technical Mission to Japan, namely, 80,000.

TABLE 3.—*Follow-up study of the fate of 16,718 school children in Hiroshima located at various distances from the center of bomb burst*

Distance (feet)	Total children	Known dead	Missing (unknown)	Wounded	Untraced (disconnected)	Healthy	Computed	
							Total deaths	Per- cent mor- tality
0-1,640-----	3,340	2,479	289	35	166	371	2,768	87
1,640-3,281----	4,683	693	481	240	1,643	1,626	1,174	37
3,281-4,921----	1,260	227	22	168	343	500	249	27
4,921-6,562----	5,121	96	14	1,123	832	3,056	110	2.6
6,562-8,202----	2,314	11	0	37	0	2,266	11	.48

2. Nagasaki

The best figures available on the casualties in Nagasaki were prepared by the Japanese for the Civilian Defense Division of USSBS and they are admittedly inadequate. They include only the number of verified deaths and the figure for injured includes only those hospitalized in Nagasaki. However, the figures given up to 6 November were: Dead—25,761; injured—30,460; and missing—1,927.

The British have taken the regional mortality rates from Hiroshima and applied them to population distribution in Nagasaki, arriving at an expected number of killed as 39,500. However, their estimate based upon pre- and post-raid populations and population movements resulted in a figure of 34,000 dead. They prefer the latter figure as probably being more nearly correct. The number of injured was estimated to be at least 60,000. The Naval Technical Mission to Japan has independently estimated the total deaths to be 45,000.

H. SUMMARY

1. The atomic bomb casualties may be divided into 3 main groups:

a. Secondary injuries consisting of blast effects, secondary burns and injuries due to falling debris.

b. Flash burns.

c. Radiation effects.

2. Secondary injuries accounted for a large

number of the immediate deaths, especially those due to falling debris. Blast effects do not appear to have been as prominent near the center as in high-explosive blasts. This is partly accounted for by the fact that the bomb was an aerial burst and partly by the long duration of positive phase of the blast. There were few reports of ruptured ear drums due to the blast. Secondary injuries occurred up to 15,000-16,000 feet from the center of the blast but beyond 7,000 feet they were usually of minor nature and were due largely to flying glass.

3. Flash burns indicate that a very high temperature was reached shortly after the bomb explosion. Survivors report feeling a heat wave at 24,000 feet, but skin burns probably did not occur beyond 15,000 feet. People in the open directly under the bomb were so severely burned that the skin was charred dark brown or black. The exposed surfaces of the skin were burned most severely but persons were burned through clothing. Japanese houses and even clothing offered some protection against flash burns within 3,000 feet of the center. Flash burns appeared to heal promptly and showed no unusual clinical features.

4. Radiation effects of the bombs have been confined to those who were in the area at the time of the bomb burst. The clinical picture has been that expected from large doses of gamma rays. Many patients experienced nausea and vomiting within 24-48 hours but then felt well for 1 to 3 weeks thereafter. They then developed fever and showed the typical picture of neutropenia and anemia. The severe cases usually died within a few days. Many thousands died of these effects in late August and early September. Few died who survived until 1 October. Most cases of radiation sickness occurred within 5,000 feet of ground zero and practically none who survived other injuries escaped the effects of radiation within 3,000 feet. The only structures of importance as shielding factors were concrete buildings. The degree of protection against radiation depended upon the distance from ground zero and the thickness of the concrete. Earth was also effective in protecting a small number of persons in air-raid shelters and behind hills in Nagasaki. Earth has less shielding value than concrete and several times the thickness was required to afford comparable protection. Clothing and Japanese (wooden) houses did not appear to have any shielding value. Sperm counts on survivors have

revealed oligospermia and aspermia in many persons who were within 5,000 feet of ground zero. Such effects may have extended further. Abortions and miscarriages were the rule in pregnant women within 3,000 feet and such effects may have extended to greater distances. The information relative to living babies born of mothers exposed to the effects of the bombs is inadequate for any

definite statement relative to radiation effects on these babies.

5. A review of all the evidence indicates that there were about 80,000 deaths in Hiroshima and about 45,000 in Nagasaki as a result of the atomic bombs. The injured probably numbered 80,000-100,000 in Hiroshima and 50,000-60,000 in Nagasaki.

IV. ENVIRONMENTAL SANITATION

A. GENERAL

1. In evaluating the effects of aerial bombing on environmental sanitation attention was devoted to the public water supply, the systems of sewage and refuse disposal, insect and rodent control, disposal of the dead, and the standards of cleanliness maintained in the dispensing of food and drink. Data were obtained not only on the damages incurred or on the extent of interruptions in service, but also on the systems existing prior to the time of the first aerial bombardment. Sources of information were the prefectural and city health departments, waterworks officials, city engineers, and at Nagasaki, the Military Government officials. A perusal of these data was the basis of the discussions and conclusions presented herewith.

2. The officials concerned with environmental sanitation were cooperative but were unable to supply detailed records concerning their activities. According to their statements all such records were destroyed in the bombing. The information obtained, while in round numbers in many cases, appeared to be reasonably correct and sufficient for the purpose of the Survey. In general, the officials appeared to be still in a state of confusion and this was admitted by some of them. Lack of records, loss of equipment, and shortage of manpower together with the apparent lack of aggressive leadership may have been responsible in part for this confusion. It should also be considered that many of these officials had lost their homes and were still concerned with matters pertaining to their own and their families' existence.

B. HIROSHIMA

1. *Water supply*

a. *Public water supply*

The public water supply is obtained from wells sunk in the bed of the Ota Gawa, about $1\frac{1}{2}$ miles north of the city. The water is filtered through uncovered slow sand filters and under normal conditions the water would be chlorinated before delivery to the distribution systems. The capacity of the plant was given as 26 million gallons per day, with an average daily consumption of 17.8 million gallons, or 45 to 50 gallons per capita. The distribution system covered the

greater part of the city and prior to the bombing supplied 90 percent of the population (estimated at 400,000).

The treatment plant had been operated under laboratory control prior to the bombing, but no records were available at the plant laboratory. All records which were forwarded to the city office and laboratory were destroyed in the bombing. The shortage of chlorine following the outbreak of war caused a break down in chlorination of the water and practically no chlorination was practiced for some time prior to the bombing.

From such evidence as was available the raw water from the river wells was free of turbidity, low in organic matter, total solids, hardness, and bacteria. It did not always meet the standards set for finished water, which is 50 bacterial colonies per milliliter, as determined by total count on nutrient agar incubated at 37° C. for 24 hours, and no coliform organisms in one milliliter, as determined by colonies on Endo medium incubated at 37° C. for 24 hours.

No information was available on the bacterial content of the water as delivered to the system during the periods just prior to and since the bombing. During these periods, however, even in the absence of chlorination it is believed that the water as delivered to the system was and is still of safe quality.

No alternate plans were made for supplying drinking water in the city in case of bombing, reliance being placed upon the numerous wells existing throughout the city.

Damage to the water system due to the bombing was primarily in the distribution system. Damage to the pumping and treatment plants was not sufficient to interfere greatly with their operations. Considerable damage occurred in the plant laboratory and much of the equipment made unserviceable. Damage to the distribution system in the city was mainly to the building and house service connections, the only major break in the large mains occurring at a river bridge crossing.

The service pipes to practically all destroyed buildings were broken or leaking, following the explosion. It was estimated

that there were approximately 70,000 of these. Nothing had been done up to the date of the Survey to shut off these broken services and prevent the excessive loss of water.

At the time of the Survey the treatment plant was operating normally, but no laboratory work had been carried on since the bombing, although the damage to the laboratory was not such as to warrant more than a few days break in carrying on essential examinations.

The whole plant was untidy, perhaps due in part to the difficulty of obtaining labor and necessary materials. The amount of water being delivered to the city was approximately 15 million gallons per day, the major part of which was being wasted through broken service pipes. The water pressure in the city had dropped to about 15 pounds per square inch and little or no water was reaching the undamaged sections of the city. It was stated that the booster station supplying the higher sections of the city was put out of service by the typhoon and was inoperative at the time of the survey (Fig. 50).

In general, therefore, the water supply as delivered from the treatment plant was probably safe but was not available to a considerable part of the existing populated sections. The low pressure and the large number of leaky services made backflow possible (Fig. 51).

A complete description of the physical works and the bomb damage sustained is contained in the report on physical damage at Hiroshima.

b. Private water supplies

At Hiroshima, as in all the coastal cities, shallow wells of both the dug and driven type abound. No estimate could be obtained as to the number of wells, but it was stated that wells were accessible to 85 percent of the population. Based on the number of wells reported in other cities, there probably are at least 15,000 in Hiroshima. These wells varied in depth from 20 to 40 feet, depending upon the topography. The larger buildings, hospitals, and factories generally had drilled wells to supplement the city supply and these were 300 feet or more in depth.

It was stated that the water from these shallow wells was not used to any extent for drinking in the delta area of the city but was used for all purposes in the outskirts and in the higher sections. In general, the shallow wells were fairly well protected from surface pollution and the pumps used were of the force-pump type. It is questionable if these shallow wells were safe for drinking purposes, however. No information was available as to the water quality.

In the bombed area all shallow wells were put out of service due to the debris and to the heat damage to pumps. These wells therefore ceased to be any health menace following the bombing.

2. Sewage and waste disposal

a. Public sewerage

The city has a sewerage system draining about 80 percent of the city, discharging the sewage without treatment through 40 outlets into the numerous rivers flowing through the city. These sewers carry very little human excreta.

As in other Japanese cities, water-carriage building systems existed only in the larger buildings, hotels, and perhaps a limited number of the more pretentious homes, but no estimate of the number of buildings having such systems was obtainable. Very few if any of these systems discharge directly to the sewers but rather to settling tanks from which the effluent passes to the sewers. Information obtained as to the number of buildings from which night soil was collected would indicate that there were very few houses having water-carriage systems. Waste water from the households discharged to drains from which it reached the sewers through catch basins.

The elevation of the city is such that gravity flow of sewage to the rivers is not possible, requiring pumping and the use of tide and flood gates on the sewer outlets. The system has 14 sewage lift-pumping stations with 3 motor-driven pumps at each station. The pumping equipment in 7 of the stations was destroyed by the bombing with some damage to the remaining 7. The typhoon of 17 September caused additional damage beyond that caused by the bomb.

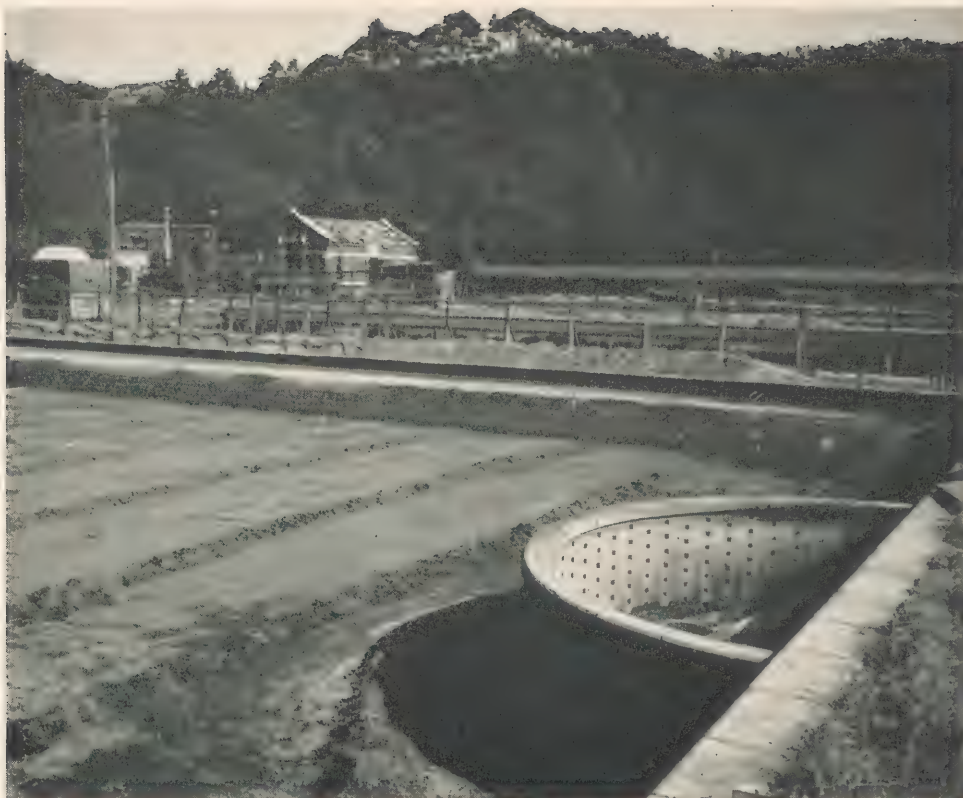


Figure 50.—Treatment plant. Public water supply. Slow sand filter unwatered and in process of being cleaned.



Figure 51.—Flush-type fire hydrant in street. Water on to supply domestic needs. Note low pressure and opportunity for back syphonage.

Some 3.5 to 4 square miles of the city was flooded due to failure of the sewage pumping stations and control gates, damaged by the bombing, to function. This flooding probably delayed to some extent rehabilitation of service structures.

A complete description of the sewerage system and the damage sustained by the bombing will be found in the report of the physical damage at Hiroshima.

b. Night soil collection and disposal

As stated under the heading of sewerage, few if any households discharge human excreta to the sewer system due to the universal use of night soil as fertilizer. Benjos (privies) were used in each household and as is usual in Japan were an integral part of the house. The statement was made that all these were equipped with watertight containers. Observations would indicate, however, that more primitive types were in use in the poorer class of households.

The number of households having Benjos of the above described type was given as 80,000. The number of buildings equipped with holdings or settling tanks was not obtainable.

Collection of night soil was made by the city, although collection by farmers was permitted, the latter collecting from about 30 percent of the households. The content of the privies was dipped and placed in the universal type of covered wooden buckets. Collection was made by the city on a semi-monthly schedule. The amount collected by the city averaged 48,000 gallons per month. The night soil collected by the city was stored in covered concrete tanks located on the water front and later transported and sold to farmers. The plan was to hold the night soil at least 30 days before its final disposition. The storage tanks, of which there were 20, were concrete, including the cover. Each tank had a capacity of 64,000 gallons. Inspection indicated that only three tanks were in use or had been used and that the installation as a whole was relatively new. Night soil from the storage tanks was delivered by the city to the farmers either by truck or boat and a charge made. The

bombing destroyed all the collection equipment and no collections have been made in the undamaged section of the city since the bombing. The storage tanks were not damaged but some reconditioning of the boats would be required before their use.

Since the bombing, disposal of night soil has been the responsibility of the householder. Official recommendations were made that insofar as possible night soil should be used as fertilizer on the small war gardens. This recommendation had also been made prior to the bombing.

Prior to the bombing there were 46 public comfort stations but none of these was connected to the sewers. At the time of the survey there were between 20 and 30 available. Some of these were of an emergency type and consisted simply of rough shelters with shallow pits.

It is believed that the health hazard existing prior to the bombing because of the methods of disposal of night soil was greatly intensified in the occupied sections of the city following the bombing.

c. Garbage and refuse collection and disposal

Garbage- and trash-collection service was maintained by the city prior to the bombing and collections were made on a once- to twice-per-week schedule. For the purpose of collection and disposal, the city was divided into five districts. Disposal was made to a low meadowland near the rivers, one in each district. From time to time the rotted garbage from which trash had been removed was disposed of to farmers for use as fertilizer. This method of disposal certainly tended toward the creation of fly-breeding places as well as rodent problems.

No information was available as to the amounts of garbage and refuse collected by the city.

The collection equipment was destroyed by the bombing and no attempt had been made to resume service in the undestroyed areas by the time of the Survey. Again, as in the case of night soil, disposal of garbage and refuse has become the duty of the individual householder or the community group.

3. *Milk and food sanitation*

a. *Milk supply*

The amount of milk used under normal conditions is so small as to make its control of little importance from a health standpoint. Milk is available only for the use of infants and pregnant women and then only on a physician's prescription. Prior to the bombing the amount of milk consumed in the city was about 570 gallons per day. All milk was pasteurized, using the holding method for 30 minutes at 63° C. The milk was pasteurized at two plants within the city and in others outside the city.

Inspection was carried on through the Prefectural Health Department and all dairies and plants are inspected twice each month. Laboratory control was also maintained through the Prefectural Health Department.

The bombing destroyed both of the pasteurization plants within the city although one had resumed partial operations at the time of the survey. The amount of milk being consumed at the time of the survey was given as 430 gallons per day.

Inspection of the dairies and existing pasteurization plants continued after the bombing on about the same schedule as before.

b. *Food sanitation:*

Food inspection, including abattoirs, was carried on under the Prefectural Health Department and has continued as before the bombing in the prefecture and the city beyond the bomb-damaged area.

It was claimed that the inspection included both the inspection of food as to quality and sanitary inspection of the food places. The number of inspectors employed in both food and milk control within the prefecture prior to the bombing was 30. The number employed normally within Hiroshima proper was not ascertainable.

4. *Insect and rodent control*

At the time of the survey the prevalence of flies during the fly season could only be estimated. The method of disposal of night soil, garbage, and other waste would indicate a rather wide prevalence. No control was exercised by the health authorities.

It was stated that there was an apparent increase in fly prevalence immediately following the bombing but the destruction of fly-breeding

places and food material by the bombing would indicate that in the bombed area particularly there should have been no more than a temporary increase.

Mosquitoes were prevalent prior to the bombing but no attempt was made by the city toward control. The excessive number of small static water containers and, after the bombing, the standing water from leaky service pipes should account for excessive mosquito problems. It was stated that dengue and malaria were not problems and that no attempt had been made since the bombing to exercise any control over mosquito breeding. No information was obtained as to the types of mosquitoes normally present.

Little information could be obtained on the relative prevalence of rodents prior to the bombing since no control was exercised by the city. It was stated, however, that if plague should occur, active measures would be undertaken toward rat extermination.

No rats were observed during the period of the survey and it is believed that the percent reduction in rat population was at least equal to the percentage of the city destroyed by the bombing. While harborages existed within the bombed area, the absence of food material made the area unattractive to rats.

5. *Disposal of dead*

The bodies of all bomb victims were cremated; no mass burials were made. The delay in disposing of dead bodies cannot be considered to have created any potential health hazards.

6. *Evacuation*

The evacuation of school children in the spring of 1945 was carried out in conformance with a national program. Firebreaks within the city were made and a considerable number of buildings destroyed. The dispossessed population was forced to find other habitation within or without the city. No information was obtainable as to the number leaving the city.

It was stated, however, that between the first evacuation movement and the time of the bombing, there appeared to be more or less movement of groups of the population, including children, in and out of the city. Consequently, the number of school children and others who were actually in evacuation areas at the time of the bombing was indeterminate. Following the bombing there was naturally a mass evacuation into the prefecture to the north of the city, but

there appeared to be little information on the number of evacuees that remained within the prefecture. It should be borne in mind that a considerable evacuation from Kure in the same prefecture has taken place following the bombing of that city on 1 July 1945.

7. *Comments*

Lack of records on the occurrence of communicable diseases since the bombing make it impossible to state what effect the interference with sanitary service had upon the prevalence of these diseases. There apparently was some increase in dysentery but health authorities were uncertain as to the extent or the probable cause.

At the time of the survey, evacuees were beginning to return to the city and occupy makeshift habitations. According to health officials, these evacuees believed that the chances of shelter and food were better in the city than in the evacuation areas where they had worn out their welcome. This movement back to the city may introduce additional local health problems.

From the standpoint of sanitation and the effect upon the services considered essential for maintenance of good sanitary conditions in a city, there appeared to be little difference in the effect of the atomic bombing of Hiroshima and the urban area bombing of other cities in Japan.

C. NAGASAKI

1. *Water supply*

a. *Public water supply*

The public water supply of Nagasaki consisted of 4 impounding reservoirs located on the southern, eastern, and northern outskirts of the city. Water from 4 of these reservoirs, known as Kogakura, Hongochi-high, Hongochi-low and Nisiyama-high, was treated by slow sand filtration and post chlorination in 4 independent plants having a combined capacity of 10,230,000 gallons per day. Flow was by gravity into the distribution system from storage reservoirs at the plants. These reservoirs had served the city for 56 years, beginning in 1889, and the supply had been adequate except during periods of severe drought such as occurred in 1939-40 (Figs. 52 and 53).

In August of 1940 construction was begun on a fifth reservoir and plant known as the Urakami supply. Treatment was to consist of coagulation, rapid sand filtration,

and post chlorination. Because of the shortage of labor and materials, however, the plant was never completed, with the exception of two of the six filters which were equipped and housed in a temporary wooden building. Thus the available supply was increased to 13.3 million gallons per day, which on the basis of 220,000 persons served, was equivalent to 60 gallons per capita per day. The total consumption at that time was approximately 10,000,000 gallons per day which is equivalent to 45 gallons per capita per day, a quantity considerably smaller than experienced in United States cities of comparable size. It should be remembered, however, that the Japanese system of plumbing is such that very little water is required for flushing purposes. Furthermore, there were an estimated 10,000 private wells scattered throughout the city which were available to some 50,000 persons as sources of water, particularly for laundry and cleaning purposes. Hence, with the additional supply made available by operation of the two rapid filters, the quantity of water was probably ample for maintaining the usual standard of cleanliness from the standpoint of public health.

Explosion of the atomic bomb on 9 August 1945 caused the collapse of the temporary building housing the two filters, damage to the equipment, and destruction of the power lines necessary for operation of the pumps for lifting the water from the clear well to distribution system. But since the other reservoirs and plants were not damaged by this blast and since the population of the city was materially reduced at that time, a shutdown of this plant did not result in a water shortage.

In regard to quality of water, little data could be obtained from records of past analyses since the laboratory building and equipment, including most of the records, were destroyed by fire following the air raids. Information obtained from the water department indicated the raw water impounded in the reservoirs to be relatively free from pollution. The filters were operated at rates considered within the ranges of good practice for water of this character and all water was purported to be chlorinated at an average rate of 0.5 parts per million before storage.

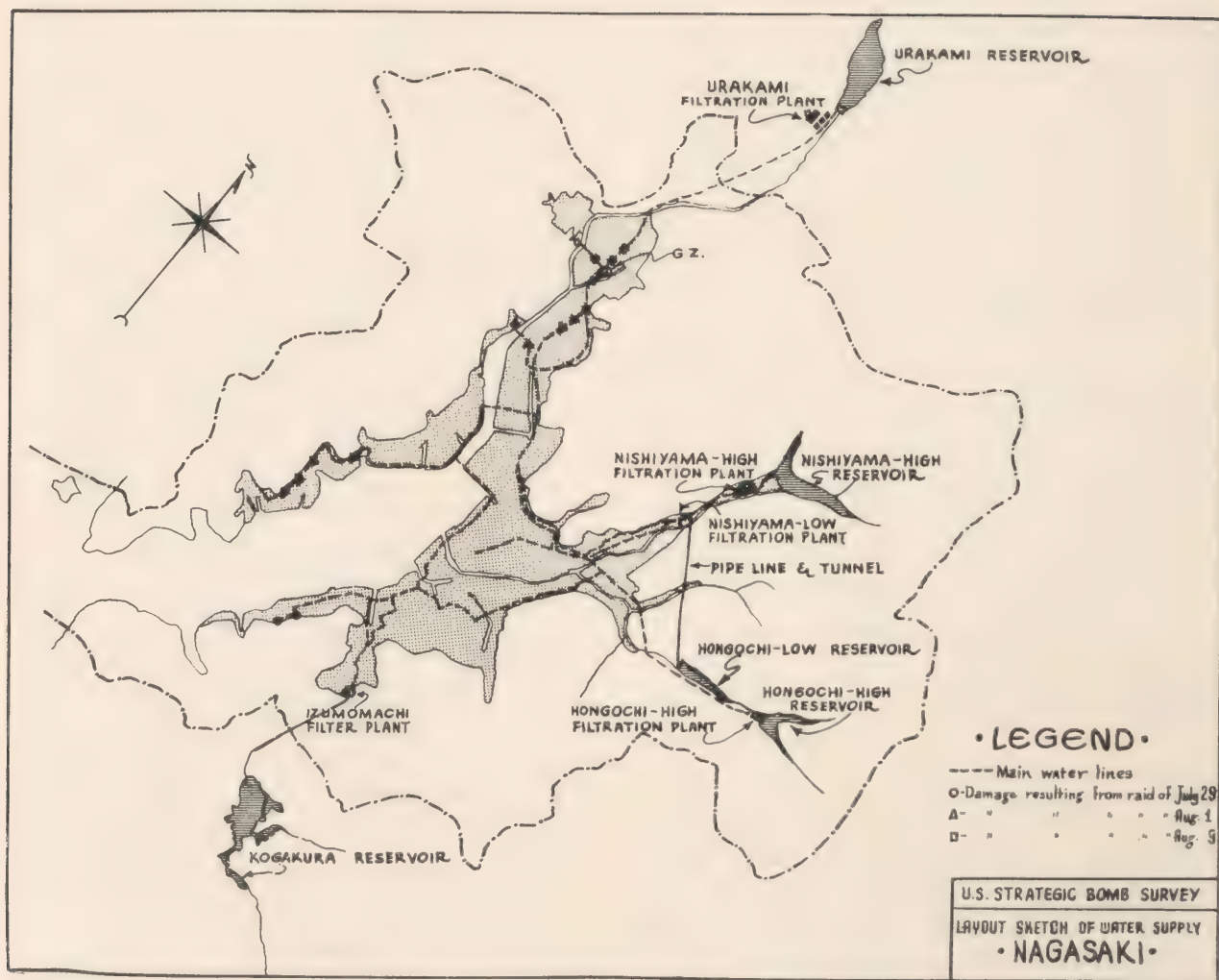


Figure 52



Figure 53.—Sand filter beds and covered storage reservoir. Hongochi-high water plant, Nagasaki.



Figure 54.—Loading "honey buckets" of night soil on canal boats for transportation to rural areas, Nagasaki.

TABLE 4.—Monthly average of daily bacterial count,
B. Coli and Residual Chlorine, Nagasaki, 1943-44

Hongochi—high plant Hongochi—high reservoir				Nishiyama—high plant Nishiyama—high reservoir		
	Bacteria per milli- liter	B. Coli per milli- liter	Res. Cl. parts per million	Bacteria per milli- liter	B. Coli per milli- liter	Res. Cl. parts per million
December 1943.....	7	0	0.09	8	0	0.07
January 1944.....	4	0	.10	8	0	.07
February 1944.....	(1)	(1)	(1)	(1)	(1)	(1)
March 1944.....	4	0	.10	(1)	(1)	(1)
April 1944.....	7	0	.08	9	0	.06
May 1944.....	9	0	.08	4	0	.08
June 1944.....	7	0	.09	18	0	.05
July 1944.....	10	0	.08	13	0	.06
August 1944.....	15	0	.06	7	0	.07
September 1944.....	(1)	(1)	(1)	(1)	(1)	(1)
October 1944.....	16	0	.06	(1)	(1)	(1)
November 1944.....	6	0	.09	9	0	.06

Nishiyama—low plant Hongochi—low reservoir				Izumomachi plant—Koga- kura reservoir		
	Bacteria per milli- liter	B. Coli per milli- liter	Res. Cl. parts per million	Bacteria per milli- liter	B. Coli per milli- liter	Res. Cl. parts per million
December 1943.....	5	0	0.09	3	0	0.07
January 1944.....	2	0	.10	3	0	.07
February 1944.....	12	0	.06	(1)	(1)	(1)
March 1944.....	7	0	.08	8	0	.06
April 1944.....	9	0	.07	2	0	.07
May 1944.....	2	0	.10	(1)	(1)	(1)
June 1944.....	7	0	.08	7	0	.06
July 1944.....	17	0	.05	8	0	.06
August 1944.....	10	0	.07	(1)	(1)	(1)
September 1944.....	(1)	(1)	(1)	(1)	(1)	(1)
October 1944.....	12	0	.06	10	0	.06
November 1944.....	(1)	(1)	(1)	15	0	.05

Urakami plant—Urakami reservoir			
	Bacteria per milli- liter	B. Coli per milli- liter	Res. Cl. parts per million
December 1943.....	17	0	0.07
January 1944.....	3	0	.12
February 1944.....	(1)	(1)	(1)
March 1944.....	(1)	(1)	(1)
April 1944.....	7	0	.10
May 1944.....	10	0	.09
June 1944.....	7	0	.10
July 1944.....	19	0	.06
August 1944.....	13	0	.08
September 1944.....	15	0	.07
October 1944.....	8	0	.10
November 1944.....	13	0	.08

1 No samples.

Data is based on 5 samples daily from the distribution system. Bacteria counts after incubation at 37° C. for 24 hours. B. Coli culture on Endo medium for 24 hours.

Table 4 is a compilation of bacteriological and chemical data on the five sources of supply for the period December 1943 to November 1944. These data cover the last year of

continuous record and it is believed that they are indicative of the quality of water being distributed before aerial bombardment began. Records of analyses conducted during the year 1945 were destroyed. Hence no information was available on the quality of water during and after the bombing attacks. However, there is no reason to believe that the quality was impaired since none of the reservoirs or filtration plants was seriously affected by aerial bombing of the city.

Indirectly, the air attacks did have an effect on the quality of water* in all cities depending upon chemicals for coagulation or disinfection. The supply of liquid chlorine to Nagasaki was seriously depleted during the war and was eliminated entirely some time prior to the first raid on the city. Whether this was due to destruction of chlorine manufacturing plants or disruption of transportation facilities is not definitely known. Nevertheless, the chief of the city water works reported that the use of liquid chlorine had to be discontinued and that chlorinated lime solution was used as a substitute. This was verified by our visit to one of the slow sand filter plants (Hongochi-High) where the liquid chlorine feed equipment appeared to be deteriorated from lack of use and where chlorinated lime solution was being used. This was some time after occupation by United States troops, however, when the supply was under their supervision, and it is questionable whether chlorine was applied continuously during the war, particularly after the air attacks.

On the other hand, it was stated that the raw water from the reservoirs was usually low in bacteria, including the coliform group, which are generally associated with disease-producing organisms. Judging from the nature and development of the watersheds supplying the reservoirs, there is little reason to doubt this statement. Although the watersheds are inhabited to some extent, there are no sewers carrying fecal material in the area and, although human feces was extensively used for fertilizing the farm land on the area, the proportion of farm land to uncultivated land is quite low and the cultivated land is laid out in such a manner that there is little run-off of fecal-bearing water into the reser-

voirs. Hence, it is doubtful whether the quality of water was seriously impaired even though chlorination was discontinued entirely, particularly in the case of those supplies treated by slow sand filtration.

In addition to the damages already mentioned, the Japanese officials reported a total of 17 breaks in the main feeder pipes of the distribution system, numerous breaks in the smaller laterals, and approximately 5,000 breaks in house service lines. High-explosive bombs dropped prior to 9 August were responsible for 16 breaks in pipes of the distribution system and 12 additional breaks occurred as a result of the 9 August atomic bomb, all of the latter being within 850 yards of ground zero. Most of these breaks were in the nature of fractures to the cast-iron pipe where it had been laid on filled ground, due to the impact of the explosion being transmitted in the form of earth pressure. In some places, however, pipe joints were loosened by the impact and the line was open to leakage. The damages to house service lines were in the nature of breaks caused by fire and destruction of the buildings. These breaks resulted in a tremendous loss of water and a disabling reduction in pressure until the line could be shut off or the break repaired. Water officials attempted to provide water to the stricken area before repairing the breaks but the pressure was too low and the effort was given up as hopeless. It was estimated that damage to the mains was repaired within 2 weeks after the raid and that most of the breaks in house services were repaired within a month. However, many house lines were observed to be leaking at the time of this survey and it is believed that many more breaks were buried in the debris. The estimate of 10,000,000 gallons per day water consumption at that time would tend to verify the belief that much leakage was occurring. No attempt was made to disinfect the repaired sections of pipe nor were samples collected to determine whether the water was bacterially satisfactory before placing the line in service.

Insofar as health hazards are concerned it is believed that the water supply was not seriously affected as a result of bomb damage. Loss of the Urakami supply would have been a serious factor had not the industrial

activities and population been reduced at the same time. However, since these decreases did occur the remaining four supplies provided sufficient water for sanitation purposes and since these supplies were not damaged, the water was of no worse quality than before the air raids took place.

The lack of chlorine for disinfection was somewhat of a factor in that good practice would dictate an increase in dosage during and following an air raid to provide an additional factor of safety in protecting the water in the distribution pipes against contamination resulting from backflow of polluted water. Where breaks in the distribution system occurred there was a definite opportunity for polluted water to be drawn into the system because of the drop in pressure. But if such pollution did occur, it apparently had no disastrous results as no major epidemic of water-borne disease that could be traced to the water supply was evident.

b. Private water supply

In the event that the main supply was destroyed, city officials planned to use the 10,000 private wells scattered throughout the city as a source of drinking water. These dug wells were approximately 3 feet in diameter and 10 to 30 feet deep. Some were provided with hand pumps, others with ropes and buckets. No particular attempt was made to protect the wells against contamination. About 50 percent had wooden covers but for the most part these were not tight fitting. Samples of water from these wells collected during a survey by city officials and students of the local medical college in October 1944 indicated 80 percent to be polluted. At that time the various owners were notified of the conditions and warned to boil the water before using. Had it been necessary to use these wells as an emergency source of drinking water, city officials intended to treat them with chlorinated lime before allowing distribution to the people.

2. Sewage and waste disposal:

a. Public sewerage

The city had no sewerage system for the collection and disposal of sewage other than street gutter drains for collection of run-off water. These drains were also used for the collection of laundry water and other similar

wastes excepting fecal material. They discharged into the local canals and contributed considerably to the pollution of these canals as evidenced by the appearance of the waters therein. Sewage from some of the larger buildings was also conveyed by drains and discharged into the canals. Buildings of the University Medical Center and hospital, however, were served by a large septic tank, the contents of which were removed periodically and buried.

b. Night soil collection and disposal

Fecal material from residences was collected in pit privies (Benjos) located adjacent to the houses and usually constructed integral with them. Prior to the first aerial attacks, night soil was collected by a private contractor and hauled to rural areas where it was sold to farmers for use as fertilizer. After the bombing of 9 August collection was discontinued because equipment was destroyed, and was not resumed until the middle of September when the city borrowed two trucks from the United States military forces and hired a force of about 40 farmers to do the work. In the meantime, householders were forced to dispose of the material as best they could, which usually meant removing it from the toilet vaults and burying it or using it for fertilizer on the small gardens adjacent to their homes. Farmers also collected the material from some of the homes in the outlying districts but they could not be depended upon for uninterrupted service (Fig. 54).

Because of the interruption in collection of this material, a definite health hazard existed within the city. Since the people could not be relied upon to dispose of the wastes properly, when the toilet vaults were permitted to overflow or when the material was dumped onto vacant areas or spread as fertilizer upon vegetable gardens, insanitary conditions existed. This condition was favorable for the spread of disease by insects and rodents and by the consumption of contaminated food by humans. It is believed, therefore, that the destruction of men and equipment by the bombing and the subsequent delay in proper disposal of night soil were responsible for the existence of a major public health hazard.

c. Garbage and refuse collection and disposal

Garbage and refuse from homes and commercial establishments was deposited in non-uniform wooden boxes, some of which were provided with covers as specified by the municipality. The city was divided into 3 sections and a force of 60 city employees collected the material at 3-day intervals using about 50 open box-type 2-wheeled carts. The material was hauled to the dock area where it was dumped into barges and transported to an island outside the harbor for incineration. Because of the peculiar eating habits of the Japanese there was very little garbage and most of the material collected was burnable or inorganic. An estimated total of 90 to 100 tons of this material was collected each day, which on the basis of 250,000 population was equivalent to approximately three-quarters of a pound per person per day. Experience in United States cities indicates a quantity of approximately twice that amount.

Since many of the vehicles used in collecting the refuse were destroyed and man power was reduced by bombing, collection of the material was discontinued after the 9 August attack. Officials stated that only 6 vehicles and 20 workmen were available for collection at the time of this survey. Preparations were being made at that time by military forces for resuming the collection and disposal program. In the meantime the people were disposing of the material by dumping on vacant areas or by burning. Because of the food shortage very little organic material accumulated in the form of garbage and it does not appear that a serious health hazard existed as a result of the interruption in collection.

3. Milk and food sanitation

a. Milk supply

Milk was not an important factor in the spread of disease either before or after the bombing. Before the war there were approximately 15 dairies with a total of 150 cows supplying in the neighborhood of 400 gallons of milk per day. One pasteurization plant was operated utilizing the "low temperature process" whereby the milk was held at a temperature of 63° to 65° C. (145 to 149° F.), for a period of 30 minutes. This process compares favorably with the United States

practice of pasteurizing at 140° F. for 30 minutes. The milk was reported to be bottled before pasteurization which is contrary to practice in the United States but which, nevertheless, was a recognized practice in Japan. Low bacteria counts (under 50,000 per ml.) were claimed but it is questionable whether this quality was maintained. Because of the extreme shortage of milk, it was not available to the public but only to infants, invalids, or nursing mothers on a physician's prescription.

As a result of aerial bombing, seven or eight dairies and the pasteurization plant were destroyed. This, of course, stopped the supply of pasteurized milk and reduced the raw milk supply to about 50 percent of pre-bombing level. Health officials were somewhat concerned about this loss and intended to arrange for importation of a supply sufficient for the needy. However, since the pre-war quantity was so small, the loss in supply is not considered to be a serious public health factor.

b. Food sanitation

Insofar as the effects of bombing on handling of other foods is concerned, it is difficult to arrive at any conclusion. Before bombing, 1 slaughter house was operated for the butchering of approximately 150 head of cattle, sheep, pigs, goats, and horses per month. This building was damaged by the atomic bomb but not seriously and could be operated if necessary. However, it was reported that many animals were slaughtered after the first bombing in anticipation of the country being occupied by United States troops. It was rumored that the invading military forces would confiscate the animals, so the Japanese felt that a pre-invasion slaughter would not only add to their food supply but would deprive the invading forces as well.

Three artificial ice plants in the city supplied ice for food preservation, most of it being used for refrigerating fish during transit to other cities in Japan. Two of these plants were destroyed by bombing but the third was operating at the time of this survey. The loss of the two plants was not important since the fishing industry had been greatly restricted during the war and the one remaining

plant was able to produce a sufficient quantity of ice for refrigeration of the small amount of fish being shipped.

4. Insect and rodent control

No regulations were in effect relative to the control of insects or rodents in either the city or the prefecture. Some control measures were practiced before the war in the way of spraying toilet buildings with kerosene against flies and setting traps or poison baits for rats. During the war, however, these materials became very scarce and it was necessary to curtail fly-control measures and to depend upon cats for preventing an increase in the rat population.

Another factor indirectly effective in the control of rats was a government directive which required the removal of wooden ceiling boards from the interior of houses in anticipation of bombing as a measure in preventing the spread of fire. In removing these boards, rat harborages between ceiling and roof were eliminated and the rodents were driven into the open where they were killed by the people or by neighborhood cats. It was also reported that the bombings and resultant fires were effective in reducing the rat population. After the aerial attacks, the remaining cats were apparently effective in the control of rat breeding, as no increase in rodent population was observed by city or prefectural officials. Actually, since the scrap food supply was very small, no increase was anticipated.

District supervisors of the Nagasaki Prefectural Health Department explained the situation this way: "During the first attacks with HE bombs, the cats ran away from the city and many rats were killed by burns and falling debris. Now the cats are coming back and are seeking homes with the people who will feed them, sometimes four or five to a family. The rats that weren't killed are also seeking food and harborages in the unbombed areas where the cats are residing and are quickly destroyed."

Flies and other insects, however, present a serious problem. After the bombings, and particularly after the 9 August attack, before the clean-up campaign had begun under supervision of the military government, flies were breeding profusely in toilet pits, garbage and refuse dumps, and other accumulations of organic material. The hundreds of small basins and receptacles for storage of water for fire protection also afforded breeding places for mosquitoes. Pools of rain water accumulating in

the ruins of bombed-out areas, roadside ditches, depressions in cemeteries, and other similar places also afforded breeding places for these insects. Although mosquito-borne diseases had not been very prevalent in Japan during prewar days, they constitute a serious threat to the public health and the increase in mosquito population should be considered a detrimental effect of aerial bombing.

The situation relative to increased fly breeding is much more serious. As pointed out in the discussion under sewage disposal, the accumulations of night soil in bombed out areas and the overflowing pits or improper disposal of this material in unbombed areas presented the opportunity for disease producing organisms to be picked up and spread by insects. Hence with an increase in the number of insects, the situation becomes greatly amplified and although the fly population had not reached an alarming number at the time of this survey, the accumulation of filth were a potential menace to the health of the people.

5. Disposal of dead

The procedure for disposal of the dead after aerial bombardment is stated in detail in the report of the Civilian Defense Division, United States Strategic Bombing Survey and need not be repeated here. As was customary in prewar days, the bodies of those killed by air raids or of those dying from injuries were cremated. When the permanent crematories did not have sufficient capacity for disposal of all the bodies such as after the 9 August raid, many bodies were cremated on piles of scrap lumber set afire for the occasion. A lapse of 20 days after the 9 August bombing was estimated for the disposal of those killed and an additional 30 days for those who died from injuries. Military government officials expressed the opinion that many bodies were buried in the debris at the time of this survey.

The time interval of 20-30 days before the bodies were cremated may have led to insanitary conditions but it was not believed to have created a definite health hazard.

D. SUMMARY

1. Even before the destruction by the atomic bombs, there had been considerable damage to

sanitary facilities at Hiroshima and Nagasaki from aerial bombing. The loss of equipment and manpower used in the Japanese system of night soil disposal had perhaps the most serious effect because it became impossible to prevent accumulations of the material in both bombed and unbombed portions of the cities. These accumulations were reservoirs of disease producing organisms and provided breeding places for flies and other insects. As a result, seriously insanitary conditions were created, with the situation ripe for the spread of disease.

2. Damages to public water supplies, such as breaks in the distribution system for house services, also created an opportunity for epidemics of water-borne diseases. These breaks, with consequent drops in pressure, provided an avenue for pollution to enter the system. Until they are repaired and normal operation is resumed, they continue to be a potential health hazard. The lack of disinfectants, caused by the destruction of manufacturing or shipping facilities, enhanced the opportunity for the spread of infection occurring in this manner.

3. Because of the damage to water distribution systems it was necessary to shut off the supply in some of the damaged areas and in certain inhabited sections of the cities. Thus the people in these areas were forced to use shallow wells as a source of drinking water. It is difficult to determine whether a serious health hazard was introduced as a result of this. Many of the wells were undoubtedly contaminated but the Japanese custom of drinking tea prepared from boiled water probably diminished the hazard. This also applies to the use of water from the public supplies, if contamination had taken place in the distribution system.

4. Garbage- and refuse-collection schedules were entirely suspended, but because of the decreased quantities of these materials, no serious insanitary conditions existed.

5. Insect and rodent control programs were not carried on by the municipalities either before or after the bombings. The rodent populations were apparently diminished in both cities, but there were increases in the number of mosquitoes.

V. FOOD SUPPLY AND NUTRITION

A. EFFECT ON FOOD SUPPLIES

1. Prior to the war both Nagasaki and Hiroshima prefectures were deficit food producing areas. In 1939, according to Army Service Forces Manual M 354-7, the production of rice in Nagasaki prefecture left a deficit of 271 pounds per person per year, as compared with a national deficit of 67 pounds. The total milk production in this prefecture for 1936 amounted to only 1.43 pound per person (compared to the apparent consumption for all Japan of 8.74 pounds and for the United States of 438 pounds for the same year). No butter was produced in Nagasaki in 1936. Similarly, the year's production of soybeans amounted to 13.41 pounds per person in 1939 as compared to a national average production of 11.54 pounds per person and a national average consumption of about 36 pounds per person. Egg production amounted to about 27 eggs per person per year and the meat products obtained from all cattle, hogs and horses slaughtered amounted to about 3.4 pounds per person per year. Nagasaki was a major fish-producing area, the average annual yield of fish for the 1935-39 period amounting to 312.75 pounds per person (the average per person consumption of fish in Japan was 95 pounds in 1936).

Army Service Forces Manual M 354-21 estimates that caloric value of the aggregate annual production of foodstuffs in this prefecture (1935, 1937 and 1939) at 1,323 million calories. Using the estimated Japanese national intake of 2,150 calories per person per day and the 1940 census figure for the population of Nagasaki (1,370,063), the normal food consumption is calculated to be about 2,946 million calories. On this basis it appears that Nagasaki prefecture normally produced only about 45 percent of the foodstuffs necessary to meet the caloric requirements of this population.

2. The situation in Hiroshima was similar, except that this prefecture was not a major fish-producing area.

3. Although Hiroshima prefecture contained, in 1939, 2.56 percent of the population of Japan proper, it had only 2.2 percent of the total rice acreage and 1.7 percent of the wheat acreage in Japan. The rice deficit in 1939 was 199 pounds

per person. The cultivated acreage per farm household in 1939 was 1.5 (Nagasaki, 2.1) while the national average was 2.7.

4. It is apparent that both Nagasaki and Hiroshima depended to a very considerable extent upon imports of food to meet the basic requirements of their populations and that the length of time that they could provide their people's needs in the absence of such imports depended greatly upon the nature, size, and availability of food stores, and the character and efficiency of their food-distribution systems. There was little possibility of increasing food production sufficiently to make up a major proportion of the food lost through the cutting off of imports; although it was possible to make some products more available for local consumption as food by discontinuing their export and various non-food uses.

5. The stocks of rice on hand normally varied considerably from spring to autumn. For example, in Nagasaki the stocks on 1 July 1939 amounted to 35,407 tons; on 1 September to 26,922; and on 1 November 1939, to 6,753 tons. The wartime situation regarding rice stocks until 1945 compared reasonably well with that of 1939, as indicated by stocks on 31 October 1944 which amounted to 6,355.5 tons (Food Control Bureau of the Ministry of Agriculture and Forestry). There were poor crops in 1944 and 1945 and a destructive typhoon in the autumn of 1945. Because of these factors and the progressive deterioration of transportation throughout the war, serious inroads were made on food stocks during the last year of the war. Rice stocks under government control in Nagasaki prefecture on 1 August 1945 totaled 13,567 tons, less than half the amount on hand in the same month in 1939. On 5 October 1945, stocks under the control of the Allied Military Government totaled only about 1,809 tons. Undoubtedly, neither the Japanese government nor the Allied Military Government possessed complete data on the rice stocks in Nagasaki prefecture, but it seems obvious that serious depreciation of stocks existed at the end of the war.

6. The bombing, because of the resultant administrative disorganization, disruption of transportation, and destruction of retail outlets and stocks, was responsible for a considerable part of the

stock depletion discovered by the Allied Military Government. However, the loss of food stocks due to destruction by bombing was relatively insignificant in both Nagasaki and Hiroshima. The destruction of rice stocks in Nagasaki in August 1945 amounted to only 5.54 percent of government-controlled stocks on hand in that area on the first of that month. The destruction by bombing of food stocks under government control and in the hands of the local food corporations is given in Tables 5 and 6. Additional data on food destruction by bombing, obtained from the Miso (soybean paste) and Shoyu (soybean sauce) industries are given in Tables 7 and 8.

TABLE 5.—*Bomb damage to stocks of staple foods, 1945*

[Includes stocks belonging to local food corporation as well as those under government control]

	Rice	Biscuit	Wheat and barley	Other grains
	<i>Metric tons</i>	<i>Metric tons</i>	<i>Metric tons</i>	<i>Metric tons</i>
Hiroshima:				
June.....	0	0	0	55.15
July.....	0	0	0	0
August.....	924.31	22.06	220.6	275.75
Total.....	924.31	22.06	220.6	330.90
Nagasaki:				
July.....	88.24	11.03	0	0
August.....	752.25	113.61	0	227.22
Total.....	840.49	124.64	0	227.22

TABLE 6.—*Bomb damage to stocks of supplementary foods*

	Hiroshima	Nagasaki
	<i>Metric tons</i>	<i>Metric tons</i>
Canned food.....	1.13	0
Sugar.....	0	0
Meat.....	0	0
Condensed milk.....	4.19	0
Powdered milk.....	7.15	4.77
Milk.....	74.89	43.68
Butter.....	0	0
Eggs.....	0	0
Beans (other than soy).....	0	0

TABLE 7.—*Food stocks of the Miso Industry damaged by bombing*

	Hiroshima	Nagasaki
	<i>Metric tons</i>	<i>Metric tons</i>
Miso.....	276.85	121.33
Rice.....	38.6	3.31
Barley and rye.....	14.34	8.82
Soybeans.....	48.53	17.7
Salt.....	18.75	3.31

TABLE 8.—*Food stocks of the Shoyu Industry damaged by bombing*

	Hiroshima	Nagasaki
	<i>Metric tons</i>	<i>Metric tons</i>
Soybeans.....	102.58	123.54
Wheat.....	54.05	122.43
Salt.....	24.27	131.26
Soybean Mash.....	2.12	3.28
Shoyu.....	99.27	199.64

7. Although stocks of cereals in Nagasaki were maintained near normal levels throughout most of the war, they were never sufficient to sustain the populace for any very protracted period of time if imports were discontinued. Table 9 lists the total stocks of cereals in the city of Nagasaki on 5 October 1945. At the per person daily rate of consumption existing at that time (338.7 grams), these stocks were sufficient to last about 24 days (population 142,748—November 1945 census).

8. Stocks were maintained by cutting down consumption. Based on disappearance of stocks, average annual per person consumption of rice for the years 1937–42 was 358 pounds. In the city of Nagasaki, October 1945, the rate of consumption of *all* cereals and soybeans was 272.3 pounds per person per year, which amounts to about 1,208 calories per day. According to an official of the Hiroshima Food Office, the basic cereal ration in Hiroshima in October 1945 amounted to 440 grams per day, or about 1,570 calories. The basic ration in Nagasaki is shown in Table 10.

9. The residents of the city of Hiroshima had little opportunity to supplement their basic ration after the bombing. The inhabitants of the city of Nagasaki were able to supplement their basic ration with some fish.

10. During the war there was a steady decrease in the amount of fishing conducted in Nagasaki prefecture until, just prior to the atomic bombing, the fishing industry was operating at only 20 percent of its prewar level, according to Etsuro Nakabe, president of the Hayashikane Fishing Co. The main cause of the decrease was the requisition of boats and men by the military. The bombing caused very few casualties among the fishermen and boats. However, the disorganization that followed the bombing caused considerable temporary interference with fishing. There was absolutely no fishing for 10 days following the bomb-

ing; but by the end of October 1945 the amount of fishing had increased to 30 percent of the prewar level.

TABLE 9.—*Daily necessities in stock on 5 October 1945—city of Nagasaki*

Variety	Quantity	Percent of total
Unhulled rice.....	¹ 870,000	74.5
Rye.....	¹ 68,250	5.8
Kaoliang.....	¹ 128,250	11.0
Soybeans.....	¹ 42,750	3.7
Starch.....	¹ 58,950	5.1
Total basic cereals.....	¹ 1,168,200	100.0
Vegetables.....	0	
Fruits.....	0	
Sugar.....	¹ 18,000	
Shoyu.....	¹ 266	
Miso.....	¹ 19,875	
Hijiki and Wakame (Sea weeds).....	¹ 31,065	
Shaved dry sardine.....	¹ 3,210	
Steamed sardine.....	¹ 13,275	
Dried cuttle fish.....	¹ 6,590	
Canned beef.....	² 60,000	
Tomato sardine.....	² 17,000	
Glucose.....	² 800	

¹ Kilograms.

² Cans.

TABLE 10.—*Basic commodity ration of cereals, as of end of October 1945*

Age	Grams uncleaned	Grams cleaned
Years:		
1-2.....	120	110
3-5.....	170	160
6-10.....	250	240
11-15.....	400	380
16-60.....	330	320
Laborer.....	400	380
Over 61.....	300	290

11. Normally about 5 percent of the fish caught in Nagasaki prefecture was canned for export and about 45 percent was dried. Only about 40 percent of the catch was normally consumed in the prefecture.

12. Neither the canning nor the drying of fish was affected by the bombing except for the immediate period after the bombing when the people did not report for work. However, since the end of the war no fish has been canned. During the last year of the war and after the war there have been no exports of fish. The reasons given by Mr. Nakabe for the cessation of exports are:

- a. Insufficient ice.
- b. Inadequate number of railroad cars.
- c. A great demand for fish locally.

13. During the war the average person in Nagasaki got fish only about once every 10 or 20 days, although the official ration was $\frac{1}{4}$ pound of fish per person per day. This ration would have required 900,000,000 kan of fish per day for the whole of Japan, whereas the supply during 1944-45 was only 200,000,000 kan per day. Nevertheless, Nagasaki was much better off in regard to fish consumption than the rest of Japan.

14. Figures furnished by the Allied Military Government in Nagasaki show that the total fish catch for the prefecture was 2,900 tons in October 1944 and 4,800 tons in October 1945, all of which was consumed in the prefecture (tonnage assumed to be in metric tons). If the total October 1945 catch was consumed in that month, it provided, on the average, only about 70 calories per person per day.

15. All food control and health authorities interviewed in Nagasaki and Hiroshima, as elsewhere in Japan, stated that farmers and fishermen fared much better than urban dwellers throughout the war. In fact, it was asserted repeatedly that no significant amount of malnutrition occurred in families of farmers or fishermen.

16. Because the producers of food generally kept more than their share for their own use, because many urban dwellers regularly supplemented their rations by expeditions into the surrounding countryside to buy food directly from the farmers, and because the black market grew steadily during the last 2 years of the war, amounting in 1945 to about 25 percent of all food produced in Japan, the official figures do not accurately reflect consumption.

17. During the last 2 years of the war, most of the inhabitants of the cities of Nagasaki and Hiroshima were not able to supplement their basic rations adequately. An equal distribution of the 1945 national supply of food would have provided only 1,782 calories per person per day (Ministry of Agriculture and Forestry), whereas the average requirement is 2,160 calories (Government Institute of Nutrition of Japan). The 1945 average daily supply of total protein per person (58 grams) although below the level recommended by the Japanese Institute of Nutrition (76 grams), is not seriously below the average of the Suggested Nutrient Allowances for China of the United States National Research Council weighted for the distribution of population in Japan (68 grams). Qualitatively, however, the protein in

the 1944-45 Japanese diet was inferior, as it included very small amounts of proteins of high biological value. Both foods of animal origin and soybeans were scarce during the last years of the war.

18. Soybeans did not prove to be as valuable an alternate source of good-quality protein as the Japanese government had hoped. The bean requires prolonged cooking (4-5 hours) to make its protein fully available and to make it palatable to the consumer. With the severe shortage of fuel that developed during the war, and the destruction of homes and facilities by bombing, the average Japanese found it necessary or convenient to boil his soybeans and rice in one pot at one time, cooking the mixture just long enough to make the rice palatable, about 30 minutes. Since they did not like the taste of the soybean when cooked for this short time, many Japanese failed to consume their rations of this potentially important source of high-grade protein.

19. The atomic bombing of Nagasaki and Hiroshima destroyed a large number of retail food outlets, destroyed and disrupted homes, severely damaged local transportation and disorganized administration. Thus a new phase of acute, severe food deprivation began for many people.

B. EFFECT ON NUTRITION

1. A report of the Physicians' Association of Japan for the first nine months of 1945, prepared from monthly reports of the District Physicians' Associations (obtained from the Japanese Institute of Public Health) state that beriberi, night blindness and "undernourishment," particularly among children, increased during the year in both Nagasaki and Hiroshima. In addition, "war swelling" and malnutrition of infants, due to lack of mothers' milk, were problems in Nagasaki. No data and no indication of the prevalence of these conditions are given.

2. Because of the destruction of medical records and facilities and the disruption of medical services by the bombing in both Hiroshima and Nagasaki, data on the incidence of malnutrition and specific deficiency diseases are not available. However, even though the great majority of the people in both cities appear to be well enough nourished to carry on the activities expected of them (5-9 November 1945) both the incidence and severity of malnutrition have been increasing since 1943 and are still increasing.

3. Doctor Tsunura of the Prefectural Health Department noted an increase in the incidence of deficiency diseases in Hiroshima between the time of the bombing on 6 August and the time of the visit of the medical team of the United States Strategic Bombing Survey (5-9 November 1945). Hiroyoshi Isuda, Chief of the Division of Infectious Diseases, Prefectural Health Department, considers malnutrition to be partly responsible for the many cases of diarrhea occurring in Hiroshima since the bombing. It has also been noted that convalescence from ordinary illness is unusually prolonged in many people (Takubo Shingo, Assistant Chief, Hiroshima Food Office). Father Siemes, Novitiate of the Society of Jesus in Nagatsuka, who observed and administered to many of those wounded in the atomic bombing of Hiroshima, noted that "many of the wounded also died because they had been weakened by undernourishment and consequently lacked in strength to recover."

4. Doctor Akizuki, physician to the Urakami hospital in Nagasaki, stated that during the war, most of his patients (private practice) had beriberi. However, most of those with beriberi also had tuberculosis or dysentery, which conditions he believes to have been seriously aggravated by the beriberi. He also stated that there was a great deal of diarrhea due to a diet that was not well balanced or sufficiently varied.

5. Doctor Akizuki had occasion to treat many victims of the bombing. According to him, many cases of delayed death were due to causes such as tuberculosis, heart disease and hypertension. Three persons with tuberculosis under his care became considerably worse following the bombing. He believes this to have been due to poor housing, congested quarters and malnutrition.

6. According to Father Monfette, director of the Urakami hospital, there were very great food problems, particularly within the city. During June, July and August of 1945 there was only one distribution of vegetables per person per month.

7. There was a particularly high mortality among babies and young adults from tuberculosis. There was also a high mortality from diarrhea in children under 6 to 7 years of age. Doctor Akizuki believes that many babies died because of maternal malnutrition during the period of pregnancy.

8. At the request of Doctor Akizuki, a member of the Medical Division visited and examined a

patient who had been injured by the atomic bombing. The patient, a 65-year-old man, was found to have marked anemia, edema and ascites,* emaciation and a classical pellagrous stomatitis. There were no burns or skin lesions of any kind. Because of the finding of pellagra in this old man, his daughter, a woman in her twenties who was presumably well except for a small flash burn on her right calf, was also examined. She demonstrated the mouth changes of a mild pellagra and definite pallor of the mucous membranes. The finding of pellagra in both these people, along with evidences of anemia and general malnutrition is significant as pellagra is claimed to be rare in Japan. None of the Japanese physicians interrogated by the Medical Division recognized pellagra in the absence of the classical skin lesions.

9. The physicians and health authorities in Nagasaki stated that scurvy was rare and none was observed by the Medical Division.

10. Anemia was a common finding in the victims of the atomic bombing. A considerable amount of this anemia was undoubtedly due to the radiation effects of the bomb. However, malnutrition was probably also an important cause and a factor in the resistance of the victims to injuries caused by the bombing. Maj. S. Berg, in charge of the laboratory work at Shinkosen Hospital for the Joint Commission for the Investigation of the Atomic Bomb, informed a member of the Medical Division that red blood cell counts of $3\frac{1}{2}$ million and hemoglobin levels of 12 grams per 100 milliliters were found to be quite common among 45 well Japanese who were selected at random from areas in the city outside of the atomic area. The blood plasma protein levels of all of these subjects were within normal limits. Of 125 victims of the atomic bombing, on whom plasma protein levels were determined at Shinkosen Hospital, 14 had plasma protein values below 6 grams per 100 milliliters of plasma.

11. According to Lt. Col. H. V. LeRoy, of the Army Atomic Bomb Mission stationed at Omura Naval Hospital, when he and his group arrived on 1 October 1945 they found the patients at the Shinkosen Hospital in poor condition because of malnutrition and lack of care. By the first of November these patients were in a critical state and all 70 were transferred to Omura Naval Hospital. Edema was found to be much more common among those patients transferred from Shinkosen Hospital (15 to 20 percent had edema)

than among those who had been taken to Omura Hospital as soon as possible after they were injured and who had been sustained on a good diet. Many of the patients with edema also had burns but there were many edematous patients without burns. Low serum protein levels (4 to 5 grams) were common, but many patients with edema had serum protein levels above the critical level. The occurrence of edema in the presence of normal levels of serum proteins was one of the most striking manifestations of malnutrition occurring in Japan. This is discussed in detail in the over-all report of the Survey's Medical Division.

12. The mortality rate was also much higher among the patients at Shinkosen Hospital than among those at Omura.

13. Blood studies conducted by Lieutenant Colonel LeRoy and the Army group at Omura on the employees of the hospital to obtain normal controls showed an average hemoglobin of $15\frac{1}{2}$ grams per 100 milliliters for males and 14 grams for females. These controls consisted of some Red Cross nurses, demobilized naval hospital corpsman and natives of the area who were given general employment in the hospital. This finding of normal blood values in these rural people is consistent with a statement made earlier in this report, that the wartime food scarcities primarily affected urban dwellers.

14. Examination of the records of patients studied at Omura hospital from 1 October 1945 to 7 November 1945 revealed that, of 319 patients studied, 285 had red blood cell counts of less than 4 million with hemoglobin levels of less than 12 grams and hematocrits of less than 35 percent. How much of this was due to the radiation effects of the bomb and how much to malnutrition remains to be determined by the physicians with the Atomic Bomb Mission.

15. Doctor Katashi Inouye, professor of Internal Medicine, Kyoto Imperial University Hospital, had as a private patient one of the victims of the bombing in Nagasaki. Two members of the Medical Division examined this patient (16 November 1945) and reviewed the records of the case. The patient had a burn on the innerside of each thigh and showed radiation effects in the form of epilation and leukopenia. The patient was injured on 8 August and was admitted to the hospital on 3 September with marked malnutrition and a clinical picture resembling that of Addison's disease. The malnutrition developed

primarily as a result of a severe anorexia that developed immediately after the bombing.

16. Professor Inouye expressed the opinion that many of the victims of the atomic bomb who died would have recovered if they had received proper food and nursing care.

17. Doctor T. Igarashi, industrial physician to the Mitsubishi factories in Nagasaki recognized malnutrition, especially beriberi, as being one of the major effects of the war upon factory workers. The employees of Mitsubishi in Nagasaki were supplied thiamine (vitamin B₁) pills from June to September, inclusive, every year during the war. A poly-vitamin preparation, containing vitamins A and D and a little vitamin B-complex, was supplied regularly to patients in the Mitsubishi hospital.

C. SUMMARY

1. The food situation in the prefectures of Nagasaki and Hiroshima began to deteriorate appreciably toward the end of 1943 and became progressively worse during 1944 and 1945. The decreasing food supply was due in part to decreasing local crop yields caused by manpower shortages on the farm and the shortage of fertilizers, but was mainly due to decreasing imports and the increasing inefficiency of the food-distribution system. The import of food into Nagasaki and Hiroshima was decreased by the Allied invasion of the Pacific islands and the blockade of Japan, by the deterioration and destruction of railroad rolling stock by bombing, by the requisitioning of cargo boats and personnel by the military and by the decrease in production in other parts of Japan. The destruction of food stocks in Hiroshima and Nagasaki by bombing was a relatively unimportant factor.

2. The rapid and marked decline in the supply of fish was due almost entirely to the requisitioning of fishing boats and their personnel by the military, although some of the decline may be attributed to the reluctance of the fishermen to venture forth in waters that had been mined by the United States air forces.

3. As the food supply became smaller, the farmers and fishermen tended more and more to keep for themselves more than their share of the available food. Coupled with this there was a deterioration in local transportation and the rapid growth of a large black market. All of

these factors acted to throw the major burden of the food shortages upon the inhabitants of the large cities, particularly upon those people in the lower economic brackets.

4. The bombing of the cities of Nagasaki and Hiroshima further aggravated the situation in these towns by destroying retail outlets, disrupting local transportation and destroying homes and family facilities for the preparation of foods.

5. No data are available for accurate computation of the extent to which the health of the people of the cities of Nagasaki and Hiroshima was affected by the inadequate food supply. However, information gathered from interviews of responsible and informed persons in these cities points to a wide prevalence of malnutrition. The most important and most common of the manifestations of malnutrition cited are:

- (a) Anemia.
- (b) Inability of mothers to nurse their infants because of lack of milk.
- (c) Decreased resistance to injury and disease.
- (d) Diarrhea.
- (e) War edema.
- (f) Beriberi.
- (g) Increased infant mortality.

The most important of the deficiencies in the diet appear to have been deficiencies of calories, high-quality proteins and members of the vitamin B-complex, particularly thiamine and niacin.

TABLE 11.—*Prevalence of reportable communicable diseases in Nagasaki City and Prefecture June–October 1944 and 1945 (total cases)*

		City					Prefecture ²				
		June	July	August ¹	September	October	June	July	August	September	October
Dysentery.....	1945	5	37	12	35	159	150	556	921	523	656
	1944	36	38	53	64	39	81	244	307	253	329
Typhoid.....	1945	7	4	3	2	0	15	35	9	13	29
	1944	3	4	8	3	8	12	16	33	14	30
Paratyphoid.....	1945	2	0	1	0	0	7	5	1	0	3
	1944	1	1	2	0	3	3	7	7	4	10
Smallpox. . .	1945	0	0	0	2	0	9	8	7	5	8
	1944	0	1	0	0	0	4	1	0	0	0
Diphtheria	1945	20	12	0	9	1	75	23	13	23	32
	1944	46	23	16	22	31	132	96	79	99	139
Scarlet Fever.....	1945	2	1	0	0	0	3	2	0	0	0
	1944	2	3	1	3	0	7	5	4	3	4
M. Meningitis.....	1945	11	5	0	0	0	19	6	3	1	2
	1944	27	13	5	3	10	44	17	9	7	13

¹ Data incomplete for August 1945 because of bombing.

² Including Nagasaki City.

NOTE.—Typhus, cholera and plague are not shown here as no cases were reported.

VI. COMMUNICABLE DISEASES

A. THE NOTIFIABLE DISEASES

1. The Japanese law for the prevention of infectious diseases requires weekly reports to be made by each city and prefecture upon the prevalence of:

- (a) Dysentery.
- (b) Typhoid fever.
- (c) Paratyphoid fever.
- (d) Typhus fever.
- (e) Smallpox.
- (f) Diphtheria.
- (g) Scarlet fever.
- (h) Epidemic meningitis.
- (i) Cholera.
- (j) Plague.

2. Information regarding the acute communicable diseases was obtained from the prefectural health authorities and at Nagasaki from the shipyards and infectious disease hospitals, and from medical officers in the headquarters of the United States Military Government. Although Japanese sickness statistics are frequently inaccurate, the information obtained locally was also checked in a general way with the Ministry of Health and Social Affairs in Tokyo.

3. Table 11 shows the prevalence of the communicable diseases which are required to be reported to the prefectural health office for both the city of Nagasaki and the prefecture during the summer and fall of 1945 with similar data for 1944 presented for comparison. It must be remembered that the population of the city dropped from about 300,000 in 1944 to about 140,000 on 1 November 1945, after the bombing on 9 August 1945, although the population of the prefecture remained substantially the same. Data for the month of August 1945 are incomplete because of the widespread confusion caused by the bombing.

4. It was indeed surprising to find that in the 3 months following the bombing there had been no major outbreak of epidemic diseases, and the only significant variation observed was a fourfold increase in dysentery cases at Nagasaki in October 1945 over the preceding month and over October 1944, as shown in Table 12. Rates based upon the estimated population show this increase more clearly as follows:

TABLE 12.—*Dysentery cases in Nagasaki in the month of October (cases per 100,000 population)*

	June	July	August	Sep- tember	October
1945	2	15	9	25	111
1944	12	13	18	21	13

From these figures it is observed that the rate for September 1945 is somewhat higher than for any month of the preceding year and that the peak rate of 111 in October, 2 months after the bombing, is more than eight times the rate of 13 for October 1944. This increase in dysentery corresponds with the experience of the survey in Germany wherein a striking increase in dysentery was reported on several occasions after heavy bombings of cities.

5. It will be noted that other filth-borne diseases such as typhoid and paratyphoid fever showed, if anything, somewhat fewer cases after the bombing, as there were only 2 cases of these diseases reported for September and October 1945 as compared with 14 for the same period in 1944 and 13 for the 2 months preceding the bombing. If data for August 1945 were included, the trend would not be altered. In discussing this apparent decrease with the health authorities, there seemed no reason to believe that it represents any serious lack of reporting of these 2 particular diseases.

6. There had been no cases of scarlet fever or meningococcic meningitis reported since the bombing and only 10 cases of diphtheria, an apparent decrease from previous experience even when the reduction in population is taken into account. There had been only occasional cases of smallpox, and no cholera, plague, or louse-borne typhus here in recent years. A few cases of smallpox developed in a neighboring village late in September and steps were being taken to revaccinate the population as this control measure had been suspended since 1943.

7. Beginning with the week of 14 October 1945, the United States Military Government at Nagasaki City began requiring daily reports from the Japanese officials on hospital cases, communicable diseases, venereal diseases, vital statistics, and sanitary facilities. Incomplete summary re-

ports for 3 weeks were available for study. The hospital in-patients and communicable disease cases were reported as follows:

TABLE 13.—*Hospital in-patients and cases of communicable diseases*

	Nagasaki City		
	1st week	2d week	3d week
Number in hospitals.....	260	220	210
Leading diagnoses:			
Bomb injuries.....	100	75	75
Dysentery.....	50	30	25
Insanity.....	22	23	23
Gonorrhea.....	10	15	15
Accidents.....	10	12	11
Leading causes of admission:			
Injuries.....	30		5
Dysentery.....	18	4	5
Known cases of communicable diseases (old and new):			
Dysentery.....	150	120	75
Typhoid.....	3	4	1
Trachoma.....	15	15	20
Polymyelitis.....	2	2	1
Malaria.....	2	0	0
Pneumonia.....	10	6	10
Smallpox.....	0	0	0
Syphilis.....	10	20	12
Tuberculosis.....	79	60	50
Gonorrhea.....	7	14	15
Chaneroid.....	4	2	2
Diphtheria.....	0	0	0

8. In the above classifications, many hospital cases and known cases of active infections were carried over from one week to the next, but the data bear out the belief of the United States Military Government officers that there were no serious outbreaks of communicable diseases within the city.

9. Inasmuch as the prefectural population of 1,445,000 was about ten times that of the present population of Nagasaki city and would be affected only slightly by the bombing as most of the evacuees stayed within the prefecture, it is of interest to note the general trends of the reportable diseases in the prefecture. It will be noted from Table 14 that the cases of dysentery in 1945 reached a midsummer peak of 921 in August with the figures for September (523) and October (656) approximating the figure for July (556). The excess for October over September is caused by the outbreak in the city. In each month shown, dysentery was two to three times as prevalent in 1945 as in 1944, both before and after the 9 August bombing, and the ratio of cases remains about the same between the same months in 1944 and 1945.

10. In studying the past trends of dysentery in the prefecture, it is of interest to note from Table 14 that there was a yearly decrease in the number of cases from 1940 through 1942 and then a sharp rise through 1944 and 1945. This trend is similar to that for all Japan. Also there was a sharp rise in 1942 and 1944 for the month of October as well as in 1945. Consequently, it is difficult to say with certainty whether the increase in October 1945 was influenced wholly by the air raids.

TABLE 14.—*Cases of dysentery in Nagasaki Prefecture June–October, 1940–45*

	June	July	August	September	October
1945.....	150	556	921	523	656
1944.....	81	244	307	253	329
1943.....	NA	NA	NA	NA	NA
1942.....	29	83	107	85	130
1941.....	83	130	156	103	61
1940.....	133	192	384	172	81

NA—Not available.

11. On the other hand, typhoid and paratyphoid fever when combined show 117 cases for these 5 months in 1945 as against 136 cases in 1944, and there is no apparent relationship to the time of the August bombing. It appears here as has been observed elsewhere in Japan that the trends of typhoid fever and dysentery are not closely related and may be quite divergent.

12. Diphtheria, scarlet fever, and meningitis also were considerably less prevalent in the prefecture in 1945 than in 1944, and the figures do not indicate any serious outbreaks. Smallpox was somewhat more prevalent in 1945 with 37 cases during this period as compared with only 5 cases in 1944. There were no cases of typhus, cholera, or plague reported in the prefecture during this time.

13. In Hiroshima, all the data regarding epidemic diseases had been destroyed and none had been collected since the bombing on 6 August 1945. An interrogation of the prefectural health officer in charge of the infectious diseases section indicated that he had no information suggesting any serious epidemics since the bombing. There had been two outbreaks with many cases of "diarrhea" since the bombing and there was considerable conjecture as to what extent this common but not specific symptom of dysentery may have been caused by malnutrition and the direct effects of

bombing, and the proportion that actually represented bacillary or amebic dysentery.

14. Dysentery has always been common in this city as shown by the yearly report for 1942 when there were 1,006 cases of dysentery with 141 deaths, making the case fatality rate 14 percent. It was also stated that since evacuees had been returning, additional cases were being brought into the city. This information is not sufficient to indicate whether there was an actual increase of dysentery in Hiroshima as in Nagasaki.

15. The same health officer stated that since the bombing 3 months previously he had heard of only two cases of typhoid fever, no typhus fever, smallpox, cholera, plague, scarlet fever, and that the prevalence of diphtheria and epidemic meningitis had not been affected by the bombing. He also stated that there had been no cholera or plague in the city for the past 5 years. There may have been a slight increase in diphtheria in the prefecture as four or five requests were being received daily for antitoxin.

B. TUBERCULOSIS

1. Tuberculosis had always been prevalent in Hiroshima and Nagasaki as in other Japanese communities but the exact number of cases was unknown, since the records were destroyed in both cities. Tuberculosis was the outstanding health problem, however, and considerable effort had been made in recent years to control this disease. In 1938 tuberculosis was the second leading cause of death in Nagasaki prefecture with an annual death rate of 193 per 100,000 as compared with a rate of 208 for all Japan and 49 in the United States. It was stated also that many of the cases reported under the leading cause of death, by pneumonia, with a death rate of 223 per 100,000 in Nagasaki prefecture in 1938, were actually a fulminating type of tuberculosis.

2. In Nagasaki city the Japanese doctors estimated that about 2 percent of the population have active tuberculosis but the United States Military Government medical officers estimated that the true figure may be five or six times this high, and was being increased by the crowding and lack of isolation of open cases. Fifty to 70 cases of active tuberculosis were being seen daily as outpatients. At the Mitsubishi shipyards, the medical director estimated that 5 percent of all applicants for work had tuberculosis, and the prevalence had increased during the war.

3. In both cities, it is too early to expect any measurable effects of the bombing on this most important health problem. It would be contrary to all public health experience, however, if the malnutrition, crowding, lack of adequate clothes and shelter, and frequent exposures to this infection, did not result in a serious increase of this disease in a highly susceptible race of people. It remains to be seen what can be done by American and Japanese health officials to arrest and control the spread of this infection.

C. VENEREAL DISEASE

1. As in other cities of Japan, the incidence of venereal diseases was very high among prostitutes and fairly high in the general adult population.

2. A survey of 337 prostitutes in Nagasaki by the United States Military Government revealed 80 percent with positive Kahn reactions indicating syphilis. The gonorrhea rates in different groups of examinations varied all the way from 20 to 100 percent, apparently depending somewhat on the thoroughness of the bacteriologic examinations. The inadequacy of the routine weekly visual examinations that were being performed somewhat irregularly by Japanese physicians is shown by the fact that among this same group of 337 prostitutes only 10 cases of syphilis had been detected and diagnosed during the past 8 months. Gonorrhea, however, had been diagnosed in 170 instances, chancroid in 10, and other infectious conditions in 11 examinations. A random cross section of 500 injured hospital patients revealed 30 percent with Kahn reactions indicating syphilis but this figure seems unduly high to be a representative sample of the adult population. The Japanese authorities in Nagasaki estimated 7 percent with syphilis but the true figure is undoubtedly higher according to medical officers in the military government.

3. In April 1944, a Government order abolished Geisha and other forms of entertainment and these persons were supposed to seek employment in industry. Shortly after the cessation of hostilities, the Geisha houses were permitted to reopen. There was now only one Geisha house in the city as 39 others had deteriorated because of economic pressure to Engi houses (a higher-type house of prostitution). The Engi had their own physicians to examine and treat them and were not registered under the local police laws, but they had not been examined until required by the military govern-

ment. The results of these examinations were not yet available. It was understood that these girls were not all prostitutes, and those who were did not necessarily prostitute with everyone.

4. There were 340 registered prostitutes in Nagasaki and an estimated 200 non-registered prostitutes on a clandestine basis. The segregated districts were posted as "off limits" but it was stated the girls often left these districts to solicit the occupation troops. The non-registered prostitutes were formerly arrested and fined by the Japanese police but this practice had largely been discontinued because these girls were usually found with the troops.

5. Although the registered prostitutes had their own hospital with two permanent physicians under the general supervision of the prefectural health authorities, little had been done to control the spread of infection. The United States Military Government had completed careful examinations of the prostitutes and was making plans for continued examinations and treatment of all those found to be infectious. It was hoped to render all the prostitutes with syphilis non-infectious and to keep them in well-segregated areas. As it was believed these districts would be opened up soon, it was also planned to provide supervision to insure that all exposed troops would take prophylactic treatments upon leaving these areas.

6. At Hiroshima, all records regarding prostitutes and venereal diseases had been destroyed by the bomb. The Geisha houses and brothels had been largely destroyed as the bomb exploded near the largest district and perhaps a majority

of the prostitutes had been killed. The effects of any dispersion of prostitutes was unknown. Several brothels had been closed by evacuation prior to the bombing. The prefectural health authorities stated that there were now no licensed prostitutes in the city, although there had been about 1,000 in the city and also some clandestine street solicitation before the bombing. While venereal diseases had not been reported, it was believed that there had been a slight increase over several years owing to wartime conditions. As the United States Military Government had not yet set up headquarters in Hiroshima, no current information was available from that source.

7. In general, it appears that sufficient time had not elapsed since the air raids to measure their effects upon the serious and largely unrecognized problem of venereal diseases. It might be conjectured that the dislocation of the economy, the dispersal and crowding of families, and the scattering of prostitutes following the destruction of brothels might well lead to greater promiscuity and an increase in venereal disease. The lack of adequate medical supplies and services would also tend to aggravate this condition. In Nagasaki, however, the action of the Military Government in causing adequate examinations of prostitutes to be made, and the uncovering and treatment of infected cases might well tend to counterbalance the unfavorable influences on the spread of venereal diseases. Also, the Military Government there was stimulating case finding and treatment among the general civilian population, a program which is always very much to be desired.

VII. INDUSTRIAL HEALTH AND HYGIENE

A. GENERAL

Specific information regarding the extent of industrial health and hygiene problems was extremely limited in Nagasaki and Hiroshima because of the burning of health department records, the transferal of key health authorities, the destruction of many industries, and the fact that only a few of the remaining industrial plants were resuming operations following occupation by United States troops.

In Nagasaki, a visit to the principal munitions and ordnance factories revealed flattened and twisted piles of ruins. The Mitsubishi sawmill, the Kaita iron works, and a machine shop were almost completely destroyed by the air raids; the arms works and the steel works were heavily damaged, sections of the shipyards and the technical schools received very substantial damage, and the Mitsubishi engine works and steel rolling mill received superficial structural damage. In Hiroshima, about 80 percent of the small industrial plants in the immediate area were destroyed, while the large steel, aircraft, rayon, munitions, and boiler plants on the outskirts of the city received moderate to slight damage. Due to the wide dispersal of these plants around the cities, the over-all damage to production capacity was limited.

Mitsubishi shipyards in Nagasaki were operating on a very reduced capacity. On 27 October they launched a 10,000-ton steel cargo ship, laid the keel for another one on 3 November, and had 5 other ships under way. Also, 1,000 oil stoves were being made for the American forces. The Mitsubishi Electrical Manufacturing Co. was ready to begin work on electrical equipment as soon as skilled labor was released. There were plans for making agricultural equipment. Other shipyards were beginning or continuing operations and 6 steel ships were under way. Buildings were not available for other operations and labor was scarce. In addition, a coal briquet plant was being rebuilt and expanded. Coke ovens were to be made, as charcoal was a critical item. Three large coal mines nearby would not be in operation until March 1946. There was a critical shortage of skilled as well as unskilled labor, to a lesser extent owing to the removal of Koreans, Chinese, and prisoners of war, and the very heavy local casualties. In several categories of skilled labor,

such as plumbers, practically all were killed by the atomic bomb because of their tendency to live in one area. In Hiroshima all plants had been shut down since the bombing but the shipyards and a few other plants were resuming limited operations.

B. INDUSTRIAL MEDICAL CARE

1. *Personnel*

In general, the larger industries provided fairly complete medical services for employees and their families. Practically all the large industrial plants engaged in war work had dispensaries, limited hospital facilities, and full-time physicians. In Hiroshima it was estimated that the industrial plants employed 30 full-time physicians, 90 part-time physicians, and 240 industrial nurses, but these numbers seem out of proportion to the number of employees, even though the industrial physicians give full medical care to workers and their families. Similar data are not available for Nagasaki, but it is known that the Mitsubishi shipyards were employing 20 physicians, and the Kawanami shipyards were employing 2 physicians, 18 nurses and 20 corpsmen.

Of the 200 practicing physicians before the bombing, 60 were killed, and 80 percent of the remainder were not in practice as the Government required their services in the various hospitals for the injured and sick.

2. *Facilities*

A visit to the Mitsubishi shipyards which are typical of very large industry, revealed a fairly large and well-equipped hospital, containing 50 rooms and 112 beds for in-patients. Two branch hospitals had been destroyed by the atomic bomb. There were many broken windows and considerable litter from the bombing, and very little effort had been made to clean up the hospital during the confused period after the bombing. Much of the medical and surgical equipment was outmoded and supplies of common drugs such as the sulfonamides, ether, sera, and opiates were seriously deficient. The 16 in-patients under treatment had the usual dirty bed covering and the usual members of the family preparing or warming food. Before the bombing, this hospital was averaging about 2,000 out-patients daily, but with the post-bombing restriction of activities and the extreme difficulties in transportation, the daily number was ranging between 200 and

300. During the war there had been about 20,000 employees in the Mitsubishi shipyards and now there were about 7,500 although about 2,000 of these were absent daily because of transportation difficulties.

3. *Treatment*

As in other large or dangerous industries under the Factory Act, all new employees were examined including a tuberculin test and sedimentation rate for evidence of tuberculosis, and an X-ray film of the chest for pulmonary disease. About 5 percent of applicants for work had shown evidence of tuberculosis and this figure had increased somewhat during the war. This high rate of tuberculosis was found to be true generally in other industries. As elsewhere, however, the important problem of syphilis was neglected. Annual examinations, which included a small X-ray film of the chest, were made on all employees, and about 1.5 percent of these were found to have developed active tuberculosis every year. Besides the examinations for tuberculosis, the preventive medical program included supplemental rations for heavy work, the routine use of vitamin B₁ during the summer months, the administration of multi-vitamins to those in poor health, and the routine administration of proprietary drugs for the prevention of hookworm and dysentery. At these shipyards the major war effects upon the workers' health were stated to be increased malnutrition, especially beriberi, tuberculosis, scabies and many other skin diseases, and dysentery. Dysentery had increased somewhat since the bombing on 9 August as in the city generally. Here, occupational diseases had been very few, pneumonia being the principal one.

4. *Safety devices*

A brief inspection of the shipyards revealed the usual lack of good housekeeping, the piles of litter and materials arranged in a helter-skelter manner, rather desultory welding and machine shop activities by the few remaining groups of workers, and the almost complete lack of proper sanitary facilities and protective devices, except for welders' helmets. One large air-raid shelter was a cave in an adjoining hill and this was so cluttered with machinery, materials, and litter that walking in and out was hazardous. As elsewhere in Japan there was no evidence anywhere of modern industrial hygiene engineering practices for safeguarding the workers' health, as was also observed elsewhere in Japan. The

cheapness of human life and the indifference of employers and the military precluded proper measures for promoting health and efficiency.

5. *Health and hygiene inspections*

According to the prefectural health authorities at Nagasaki, industrial health and hygiene inspections are handled by the labor section in the Police Department. This section calls upon doctors from the health department concerning occupational diseases and other health conditions, and also depends upon the medical staff of the Mitsubishi hospital. The city health office had no doctors for industrial health inspections. Physicians from the prefectural office were supposed to inspect factories and work shops to check the physical examination records and also to insure healthful conditions of work.

6. *Physical examinations*

In general, it was stated that monthly physical examinations were supposed to be made in industrial plants with more than 200 employees, but reports were not required by the prefecture. To those found to be in poor health, special rations were given in addition to those supplied all laborers. Workers absent more than 14 days must be examined, and, if found to be ill, are sent to the hospital. If a worker became ill while at home, either he or a relative was required to report the fact to a plant official. Workers injured on duty were examined, treated, and the cause determined. Occupational diseases were similarly treated but reports on their occurrence were not submitted during the war.

C. EFFECTS OF ATOMIC BOMBING ON WORKERS

1. *Working conditions*

Before the war the usual factory hours here were from 0800 to 1700 hours with an hour allotted for lunch and rest periods. During the war, however, with suspension of many provisions of the Factory Act, men usually worked from 12 and often up to 14 hours a day, and night shifts were common. Women were employed night and day but were not required to work more than 11 hours. Children under 15 years of age were permitted to work 8 to 10 hours by day. Women in good health were given the same jobs as men, whereas those in poor health were given suitable jobs such as clerical work. Many of the larger plants provided nearby dormitories with a few recreational facilities.

2. *Worker casualties*

At Hiroshima, only general information from the prefectural health officials was available. It was stated that most industrial activities had been stopped after the bombing of 6 August 1945 in the large burnt-out area. Only 26 percent of the total industrial capacity of the city was destroyed, however, as the ten largest industries employing 64 percent of the city's industrial workers were on the perimeter of the city, according to the Urban Areas Division of the Survey. The capitulation of Japan shortly after the bombing caused these plants to limit production sharply because of uncertainty as to the future and possible reconversion. In these outlying plants only 1.8 percent of the employees were killed, and 4.2 percent injured by the atomic bomb, because the workers were in these distant plants at the time. The casualty rates among the remaining workers employed in the many small industrial shops and households in the destroyed area were not known but were probably somewhat less than those of the general population, many of whom were on the streets at the time. One Japanese official estimated that about 80 percent of the plants and plant medical facilities and personnel in the destroyed area had been rendered ineffective by the bombing and that about 45 percent of the workers had been killed and 40 percent injured. Burns and missile wounds were probably the chief causes of injury and death.

3. *Absenteeism*

At these shipyards, sick absenteeism averaged 7.7 percent during the first 4 years of the war and rose to 8.7 percent in the spring of 1945. Similar figures given for injury rates averaged 4.0 percent for the first 3 years of the war and rose to 5.1 in the fall of 1944 and 4.8 in the spring of 1945. It was stated that since the surrender the injury rate had fallen sharply because of the lay-off of unskilled workers and students, the marked reduction in operations, and the reduction of working hours. The sickness rate, however, was apparently unchanged as the lay-off of students, of men in poor health, was offset by the increased malnutrition, insufficient medical supplies, and the direct and indirect effect of the atomic bomb. The number of workers absent because of transportation difficulties had been very high since the bombing.

4. *Occupational diseases*

Before the bombing there had been no outstand-

ing occupational disease problems here except for illness from paint and solvent vapor in the aircraft parts plants, and "nervous breakdowns" and fatigue induced by long hours of work, loss of sleep, inadequate lighting, and generally poor and unsanitary conditions in the factories. Absenteeism rose gradually from about 10 percent in 1938 to 17 percent in 1945. Sickness, chiefly tuberculosis and colds, accounted for 50 percent, injuries for 20 percent, and no reason was given for the other 30 percent.

D. SUMMARY

1. The effects of the air raids upon industrial health and hygiene problems in Hiroshima and Nagasaki varied considerably from other industrial areas in that many industries, workers' medical services, and the workers' homes were wiped out in a single blow. Consequently, a large number of industrial workers either became casualties, or homeless and unemployed vagrants seeking safety, shelter, and food. At the time of the survey there were not many industrial plants attempting to resume activities, and these were on a limited scale.

2. During the war years, before the atomic bombing, there had been a serious deterioration of the health supervision and medical services available to the workers. With lessening of the food supplies, long hours of work, and very inferior sanitary facilities and health supervision, absenteeism because of tuberculosis, respiratory infections, malnutrition, skin diseases, dysentery, and digestive disorders was greatly increased. The necessity of frequently foraging for food was also a major cause of absenteeism. The overwhelming catastrophe of the bombing undoubtedly aggravated the prevalence and severity of these illnesses by the drastic disruption of medical services, food supplies, shelter, and transportation, and by the frantic evacuation of many of those not seriously injured. The only immediate changes noted over the wartime trends was a moderate increase in cases of dysentery and malnutrition and an anticipated increase in the prevalence of tuberculosis.

3. The chief effects of the bombing upon the workers' health aside from the direct casualties, were said to be an increase in malnutrition, gastro-intestinal disorders, respiratory diseases and probably an increase in tuberculosis.

VIII. SUMMARY AND CONCLUSIONS

The report of the Medical Division on the effect of the atomic bombs leads to certain definite conclusions. The public health and sanitary aspects of Hiroshima and Nagasaki as a result of atomic bombing varied little from the effects of demolition and incendiary raids seen in other Japanese cities. From a purely medical aspect, however, there was a very wide difference in the number and nature of the casualties and the psychological reaction of the general population. The casualties will be discussed below. The psychological effects were evident by the mass exodus of the people to outlying areas with little regard for care of the casualties, the complete apathy of the population, the inability of the public authorities toward restoration of sanitary facilities and the supply of an adequate and safe water supply.

The almost complete destruction of medical facilities and supplies in the two cities contributed to the number of total deaths, especially among the more seriously burned who were not killed outright. It is questionable how many of the radiation deaths could have been prevented by more vigorous and competent medical care. In Hiroshima all of the hospitals were destroyed or so seriously damaged that they were rendered ineffective. Sixty of the 200 physicians in the city were killed and many others injured. It took the authorities 3 days after the bombing to restore any semblance of organized medical care. The situation in Nagasaki was even more grave as the large university hospital which contained three-quarters of the city's hospital beds was located within 1 kilometer of the blast and was completely demolished from a functional standpoint. The injured who fled to the hills received practically no medical care though a few were successful in reaching distant cities where they may have received some treatment.

The one outstanding feature of the atomic bombs was their ability to produce casualties. Since no accurate counts were available the figures given represent approximations. After studying all of the available evidence the British Mission estimated 34,000 deaths in Nagasaki and 70,000–90,000 in Hiroshima. A very recent estimate of the Naval Technical Mission to Japan has given comparable figures for the total deaths: Nagasaki

—45,000, and Hiroshima—80,000. It seems fairly generally agreed that an additional 60,000 were injured in Nagasaki and 80,000–100,000 in Hiroshima. The figures for fatalities and injured were difficult to estimate since a number of persons fled to nearby hills where they died later and were not reported and many others were transported to distant cities for treatment and were difficult to trace.

The nature of the casualties differed from those encountered in demolition or incendiary raids. There were, of course, the same type of injuries and fire burns found in other cities due to falling structures and primary or secondary fires, but in addition, there were thousands of casualties due to flash burns and other radiation effects. The number showing true blast effects was comparatively small. Flash burns were common up to a distance of 4–5 kilometers from ground zero. Sickness from gamma rays occurred among almost all who escaped death from other injuries within 1 kilometer and effects were seen as far out as 3 kilometers. These latter cases did not develop for several days to a few weeks after the explosion of the bomb. Deaths from all causes decreased sharply during the latter part of September and few have occurred since 1 October. There is no evidence that there is sufficient residual radioactivity in the target areas to be dangerous to man.

A clearer understanding of the tremendous damage to human life caused by the atomic bomb may be obtained by comparing its estimated effect on the five largest cities of Japan with the actual number of casualties for these cities as a result of other bombing. This comparison will take into account, out of the large number of variables involved, only the primary factors of the percentage of the population injured and killed and the percentage of the built-up areas destroyed. Estimated casualties for Hiroshima and Nagasaki, resulting from the atomic bomb, averaged 30 percent of their population for injuries and 22 percent for deaths. These percentages applied to the population of the five largest cities which were bombed—namely Tokyo, Yokohama, Osaka, Kobe and Nagoya—indicate that a total of 5,600,000 persons would have been injured and killed in these five cities had they been subjected to atomic

bombing sufficient to produce casualties proportionate to those suffered in Hiroshima and Nagasaki. The actual number of casualties for these five cities was 339,200, consisting of 211,673 injuries and 127,527 deaths. However, the percentage of their built-up area which was destroyed was slightly smaller than that of Hiroshima and Nagasaki, the respective percentages being 41.4 and 60.3 percent. If 60.3 percent of the area of these five cities had been destroyed by other than atomic bombing it is estimated that there would have been a total of 494,054 casualties. Comparison of this total with that of 5,600,000 mentioned above as the estimated atomic bomb casualties for these cities, indicated that the damage to life at the rate experienced in Hiroshima and Nagasaki would have produced casualties totaling 11.3 times as many as were reported by these cities as a result of the bombing they did suffer. If injuries and deaths are considered separately the number of injuries from atomic bombing would have been 10.5 times as large as that actually experienced and the number of deaths 12.8 times as large.

Actual totals of injuries and deaths reported by these cities as the result of bombing compared with corresponding estimated totals as a result of atomic bombing are shown below:

TABLE 15.—*Comparison of casualty effects of incendiary HE raids and of atomic bomb raids*

	Actual bombing casualties (41.3 percent of built-up area destroyed)	Actual bombing casualties had 60.3 percent of built-up area been destroyed	Estimated atomic bombing results	Ratio of atomic and other bombing results
Injuries.....	211, 673	308, 309	3, 225, 000	10. 5
Deaths.....	127, 527	185, 745	2, 375, 000	12. 8
Total.....	339, 200	494, 054	5, 600, 000	11. 3

One factor not taken into account above, which figures largely in the damage to life as a result of bombing of any sort is the element of surprise. In both the Hiroshima and Nagasaki bombing, most of the people in these cities were surprised and hence unprepared. The bombing of Tokyo on 9 March 1945 is somewhat comparable to that of Hiroshima and Nagasaki concerning the element of surprise. If the casualties of this bombing are compared with those of Hiroshima and Nagasaki on the basis used above for the five

largest cities it is found that the Hiroshima and Nagasaki totals drop from 11.3 times to 4.6 times those produced by other bombing.

Other outstanding factors, responsible for differing casualty totals resulting from bombing, are (1) varying densities of population and (2) the fact that the pattern of damage produced by a single atomic bomb with its damage extending over a wide area but reducing in intensity as distance from the center of explosion is increased is essentially different from that of other bombing in which many bombs are dropped each with its relatively small area of damage. No effort has been made in the above comparison to consider the effect of these and other factors which, while relatively minor, still had a part in producing the difference in results noted.

Many effects of the bombing would naturally have had a tendency to cause epidemics and impairment of public health. The principal effects were the destruction of houses with consequent crowding and exposure, the disorganization of food supplies, the destruction of sanitary facilities, and the lack of fuel and detergents. Despite these potentially serious disease-producing conditions there was no major epidemic in these cities and few measurable effects were seen upon the incidence of diseases normally prevalent. There was an increase in the number of cases of dysentery in Nagasaki which reached its peak in October, 2 months after the bombing. A similar increase may have been present in Hiroshima. The local effects of the typhoons which occurred in September and early October upon the water supply and excreta disposal must also be taken into consideration. Nevertheless, these outbreaks were not as severe as the epidemic of dysentery in Nagoya or of typhoid and paratyphoid at Kobe which began soon after the June air raids and reached their peaks in August. Tuberculosis, the most serious health problem in Japan, has shown no measurable change in the short period of time which has elapsed, but may well show an increase in the following months due to the superimposed effects of the bombing upon existing war conditions.

Malnutrition, always a problem in Japan, has undoubtedly been aggravated by the war, but it is evident that the atomic bombing was not of first importance as a cause of the already prevalent malnutrition in these two cities. Numerous cases

of malnutrition, including a few cases of pellagra, were observed and beriberi was reported to be common.

Venereal disease and its control in these two cities appeared to be no different from the problem in other cities of Japan. Syphilis is a serious problem which seems to be poorly appreciated by the Japanese health authorities but it has no direct relation to bombing.

The effects of the air raids upon industrial health and hygiene problems in Hiroshima and Nagasaki varied considerably from other industrial areas of Japan. Instead of being subjected to repeated raids, a large proportion of the industrial workers with a single blow, became either casualties or homeless and unemployed vagrants seeking safety, shelter, and food.

Except for a few specific effects of the atomic bombs one finds great difficulty in differentiating the general public health picture from that of the war-torn Japanese cities in general. Throughout the war there had been a serious deterioration of health supervision and medical facilities. With

the lessening of the food supplies, long working hours, and inadequate medical and health supervision, there was a gradual increase in industrial absenteeism. The necessity of foraging for food was also a major problem to the Japanese common man. The overwhelming catastrophe of the atomic bombs when superimposed upon these factors resulted in a state of chaos in those areas. All thoughts except that of self-preservation seem to have been forgotten. This frantic evacuation of the target areas probably helped to prevent any large disease outbreaks in the areas themselves. All the densely populated area of Hiroshima and the sizable target area of Nagasaki were almost deserted for some time after the bombing. How such large numbers could have fled to surrounding areas, and how the remaining population could have existed under such disrupted conditions of living without resulting epidemics is still difficult to understand, but there were no major outbreaks. The gradual reoccupation has allowed sufficient time for the reestablishment of facilities for medical care and sanitation.

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LIST OF REPORTS

The following is a bibliography of reports resulting from the Survey's studies of the European and Pacific wars. Those reports marked with an asterisk (*) may be purchased from the Superintendent of Documents at the Government Printing Office, Washington, D. C.

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- 25 Luftschiffbau, Zeppelin G m b H, Friedrichshafen on Bodensee, Germany
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- 94 Effects of the Four Thousand Pound Bomb on Japanese Targets (a Report on Five Incidents)
- 95 Effects of Two Thousand, One Thousand, and Five Hundred Pound Bombs on Japanese Targets (a Report on Eight Incidents)
- 96 A Report on Physical Damage in Japan (Summary Report)

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